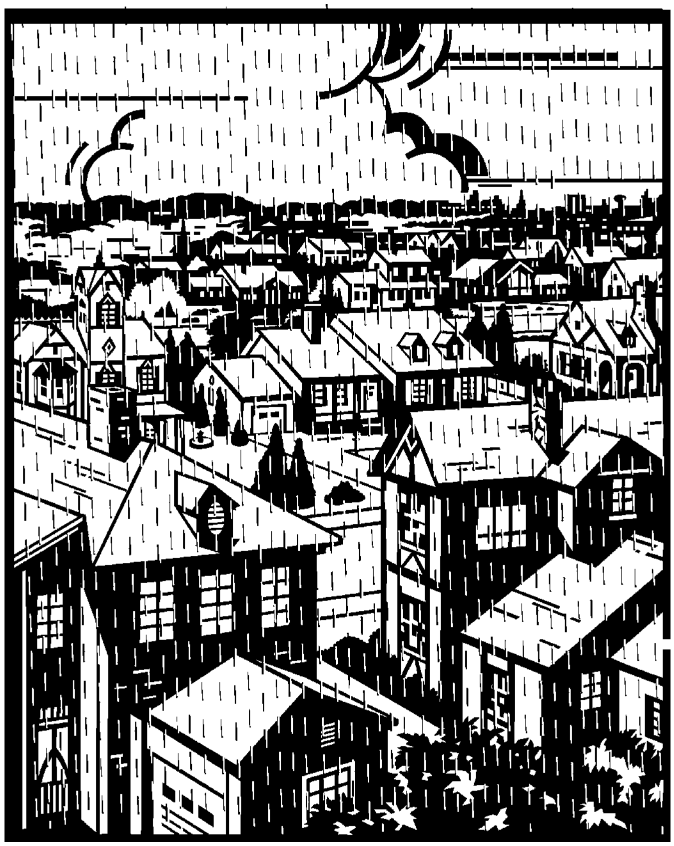
Development Planning for Storm Water Management



September 2002

A Manual for the Standard Urban Storm Water Mitigation Plan (SUSMP)

Los Angeles County Department of Public Works

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INTRODUCTION

SECTION 1 INTRODUCTION

1.1 BACKGROUND

Urban and stormwater runoff is a serious concern, in both the dry and rainy season. Studies have shown that stormwater runoff from urban and industrial areas typically contain the same general types of pollutants that are often found in wastewater from industrial discharges. Pollutants commonly found in stormwater runoff include heavy metals, pesticides, herbicides, fertilizer, animal droppings, trash, food wastes, and synthetic organic compounds such as fuels, waste oils, solvents, lubricants, and grease[1]. Waters that flow over streets, parking lots, construction sites and industrial facilities carry these pollutants through the storm drain network directly to the lakes, streams and beaches of southern California.

These compounds can have damaging effects on both human health and aquatic ecosystems. In addition to pollutants, the high volumes of stormwater discharged from the storm drain system in areas of rapid urbanization have had significant impacts on aquatic ecosystems due to physical modifications such as bank erosion and widening of channels[2].

Water Quality Assessments conducted by the Regional Water Quality Control Board (Regional Board) identified impairment of a number of water bodies in Los Angeles County[3]. The beneficial uses of certain water bodies specifically identified in these assessments are either impaired or threaten to be impaired. Pollutants found causing impairment include: heavy metals, coliform, enteric viruses, pesticides, nutrients, polycyclic aromatic hydrocarbons, polychlorinated biphenyls, organic solvents, sediments, trash, debris, algae, scum, and odor. An epidemiological study conducted during the summer of 1995 for the Santa Monica Bay Restoration Project (SMBRP) demonstrated that there is an increased risk of acute illnesses caused by swimming near flowing storm drain outlets in Santa Monica Bay[4].

The Regional Board therefore considers stormwater and urban runoff discharges to be significant sources of pollutants that may be causing, threatening to cause, or contributing

[1] *Surface Runoff to the Southern California Bight* and, *Characteristics of Effluents from Large Municipal Wastewater Treatment Facilities in 1990 and 1991*, SCCWRP Annual Report 1990-1991 and 1991-1992 (1993); Pitt and Field, *Hazardous and Toxic Wastes Associated with Urban Storm Water Runoff*, In Proceedings of the Sixteenth Annual RREL Hazardous Waste Reduction Symposium, Document No. EPA 600-9-90-037 (1990); *Storm Runoff in Los Angeles and Ventura Counties, Final Report*, California Regional Water Quality Control Board, Los Angeles Region (1988).

[2] *Fundamentals of Urban Storm Water Management*, Terrene Institute and USEPA, (1994); *Guidance Manual for the Preparation of Part 2 of the NPDES Permit Applications for Discharges from Municipal Separate Storm Sewer Systems*, USEPA, Document No. EPA 833-B-92-002 (1992).

[3] *Proposed 1998 List of Impaired Surface Waters*, Regional Water Quality Control Board, Los Angeles Region (1998).

[4] *An Epidemiological Study of Possible Adverse Health Effects of Swimming in Santa Monica Bay*, SMBRP (1996).

to the impairment of the water quality and beneficial uses of the receiving water bodies in Los Angeles County.

Urban runoff is considered to be one of the largest sources of pollution to the waterway and coastal areas of the United States. Locally, we see the impacts in increased health risks to swimmers near storm drains, high concentrations of toxic metals in harbor and ocean sediments, and toxicity to aquatic life. These impacts translate into losses to the County's annual tourism economy, loss of recreational resources, dramatic cost increases for cleaning up contaminated sediments and impaired function and vitality of our natural resources.

In the ongoing effort to improve the quality of stormwater runoff and groundwater within Los Angeles County, the Department of Public Works, in conjunction with other involved stakeholders, has organized a BMP Task Force for the purpose of providing and discussing Best Management Practices (BMP) related matters. The BMP Task Force has developed the website www.BMPLA.org in order to share information about the selection and implementation of effective BMPs.

1.2 LEGAL FRAMEWORK

In 1987, the Federal Water Pollution Control Act (also referred to as the Clean Water Act [CWA]) was amended to provide that the discharge of pollutants to waters of the United States from stormwater is effectively prohibited, unless the discharge is in compliance with a National Pollutant Discharge Elimination System (NPDES) Permit. The 1987 amendments to the CWA added Section 402(p) which established a framework for regulating municipal, industrial and construction stormwater discharges under the NPDES program. In California, these permits are issued through the State Water Resources Control Board (SWRCB) and the nine Regional Water Quality Control Boards.

On December 13, 2001, the Regional Water Quality Control Board, Los Angeles Region (RWQCB), adopted Order No. 01-182. This Order is the NPDES Permit (NPDES No. CAS004001) for municipal stormwater and urban runoff discharges within the County of Los Angeles.

As adopted in December 2001, the requirements of Order No. 01-182 (the “Permit”) covers 84 cities and the unincorporated areas of Los Angeles County, with the exception of the portion of Los Angeles County in the Antelope Valley including the cities of Lancaster and Palmdale, the City of Long Beach, and the City of Avalon. Under the Permit, the Los Angeles County Flood Control District is designated as the Principal Permittee; the County of Los Angeles along with the 84 incorporated cities are designated as Permittees. The

Principal Permittee coordinates and facilitates activities necessary to comply with the requirements of the Permit, but is not responsible for ensuring compliance of any of the Permittees.

In compliance with the Permit, the Permittees have implemented a stormwater quality management program (SQMP) with the ultimate goal of accomplishing the requirements of the Permit and reducing the amount of pollutants in stormwater and urban runoff. The SQMP is broken up into six separate programs as outlined in the Permit. These programs are Public Information and Participation, Industrial/Commercial Facilities, Development Planning, Development Construction, Public Agency Activities, and Illicit Connection/Illicit Discharge. Each Permittee is required by the Permit to have implemented these programs by February 1, 2002.

1.3 STANDARD URBAN STORMWATER MITIGATION PLAN

One specific requirement of the Development Planning Program is the Standard Urban Stormwater Mitigation Plan (SUSMP). This manual serves as a guideline for compliance with this SUSMP. The SUSMP outlines the necessary Best Management Practices (BMPs) which must be incorporated into design plans for the following categories of development and/or redevelopment[5]:

1. Single-family hillside[6] homes (only development of one acre or more of surface area is subject to the SUSMP numerical design criteria requirement);
2. Ten or more unit homes (includes single family homes, multifamily homes, condominiums, and apartments);
3. Automotive service facilities (SIC codes 5013, 5014, 5541, 7532-7534, and 7536-7539);
4. Restaurants (SIC code 5812);
5. 100,000 or more square-feet of impervious surface in industrial/commercial

[5]"Redevelopment" means land-disturbing activity that results in the creation, addition, or replacement of 5,000 square feet or more of impervious surface area on an already developed site. Redevelopment includes, but is not limited to: the expansion of a building footprint; addition or replacement of a structure; replacement of impervious surface area that is not part of a routine maintenance activity; and land disturbing activities related to structural or impervious surfaces. It does not include routine maintenance to maintain original line and grade, hydraulic capacity, or original purpose of facility, nor does it include emergency construction activities required to immediately protect public health and safety. Where redevelopment results in an increase of less than fifty percent of the impervious surfaces of a previously existing development, and the existing development was not subject to these SUSMPs, the Design Standards apply only to the addition, and not to the entire development.

[6]"Hillside" means property located in an area with known erosive soil conditions, where the development contemplates grading on any natural slope that is 25% or greater and where grading contemplates cut or fill slopes.

development; [7,8]

6. Retail gasoline outlet;
7. Parking lot 5,000 square feet or more of surface area or with 25 or more parking spaces;
8. Redevelopment projects in subject categories that meet redevelopment thresholds; and
9. Location within or directly adjacent to or discharging directly to an environmentally sensitive area if the discharge is likely to impact a sensitive biological species or habitat and the development creates 2500 square feet or more of impervious surface.

Development and/or redevelopment projects having the following characteristics or activities will be required to address the applicable sections of the above-mentioned SUSMP when completing the project design:

1. vehicle or equipment fueling areas;
2. vehicle or equipment maintenance areas, including washing and repair;
3. commercial or industrial waste handling or storage;
4. outdoor handling or storage of hazardous materials;
5. outdoor manufacturing areas;
6. outdoor food handling or processing;
7. outdoor animal care, confinement, or slaughter; or
8. outdoor horticulture activities.

The following are specific requirements for single-family hillside homes given by the Permit in order to reduce the impact of the development on the natural areas:

1. conserve natural areas;
2. protect slopes and channels;
3. provide storm drain system stenciling and signage;
4. divert roof runoff to vegetated areas before discharging unless the diversion would result in slope instability; and
5. direct surface flow to vegetated areas before discharge unless the diversion would result in slope instability.

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[7]100,000 Square Foot Industrial/Commercial Development means any commercial development that creates at least 100,000 square feet of impermeable area, including parking area. SUSMP and post-construction control requirements shall be implemented for Industrial Commercial Development of one acre (43,560 square feet) no later than March 3, 2003.

[8]Commercial Development means any development on private land that is not heavy industrial or residential. The category includes, but is not limited to: hospitals, laboratories and other medical facilities, educational institutions, recreational facilities, plant nurseries, multi-apartment buildings, car wash facilities, mini-malls, and other business complexes, shopping malls, hotels, office buildings, public warehouses and other light industrial complexes.

Section 2

PERMITTING AND INSPECTION OF SUSMP

SECTION 2 PERMITTING & INSPECTION OF SUSMP

2.1 GENERAL DESCRIPTION OF PERMITTING & INSPECTION OF SUSMP

Any project submitted to the County for review and approval may be subject to the requirements of the NPDES Permit. Development and redevelopment projects submitted for review and approval will be screened to determine if a SUSMP is required.

All development and redevelopment projects falling into either Part A or Part B of the following table, will be required to submit a drainage concept and stormwater quality plan. Details of facilities and measures which mitigate impacts to water quality would then be shown on improvement plans and reviewed as part of those plans.

To assist in the preparation of this plan, a SUSMP has been developed for the eight project types listed in Part A of the following table. This SUSMP outlines the BMPs to be incorporated into the project design. Development and redevelopment projects having characteristics or activities listed in Part B of the table will be required to address the applicable sections of the above-mentioned SUSMP when completing the project design.

Table 2-1 **SUSMP Project Types, Characteristics, & Activities**
Part A. Type of Proposed Project:
10+ home subdivision
100,000+ square-foot commercial development [1, 2]
Automotive repair shop (SIC codes 5013, 5014, 5541, 7532-7534, and 7536-7539) [3]
Retail gasoline outlet
Restaurant (SIC code 5812) [4]
Hillside-located single-family dwelling [5]
Parking lots 5,000 square feet or more of surface area or with 25 or more parking spaces
Redevelopment projects in subject categories that meet redevelopment thresholds [6]
Projects located within or directly adjacent to or discharging directly to an environmentally sensitive area if the discharge is likely to impact a sensitive biological species or habitat and the development creates 2500 square feet or more of impervious surface area.

Table 2-1 (continued) SUSMP Project Types, Characteristics, & Activities
Part B. Project Characteristics or Activities:
Vehicle or equipment fueling areas;
Vehicle or equipment maintenance areas, including washing and repair;
Commercial or industrial waste handling or storage;
Outdoor handling or storage of hazardous materials;
Outdoor manufacturing areas;
Outdoor food handling or processing;
Outdoor animal care, confinement, or slaughter; or
Outdoor horticulture activities.

[1] "100,000 Square Foot Commercial Development" means any commercial development that creates at least 100,000 square feet of impermeable area, including parking areas. SUSMP and post-construction control requirements shall be implemented for Industrial Commercial Development of one acre (43,560 square feet) no later than March 3, 2003.

[2] "Commercial Development" means any development on private land that is not heavy industrial or residential. The category includes, but is not limited to: hospitals, laboratories and other medical facilities, educational institutions, recreational facilities, plant nurseries, multi-apartment buildings, car wash facilities, mini-malls and other business complexes, shopping malls, hotels, office buildings, public warehouses and other light industrial complexes.

[3] "Automotive Repair Shop" means a facility that is categorized in any one of the following Standard Industrial Classification (SIC) codes: 5013, 5014, 5541, 7532-7534, or 7536-7539.

[4] "Restaurant" means a stand-alone facility that sells prepared foods and drinks for consumption, including stationary lunch counters and refreshment stands selling prepared foods and drinks for immediate consumption, (SIC code 5812).

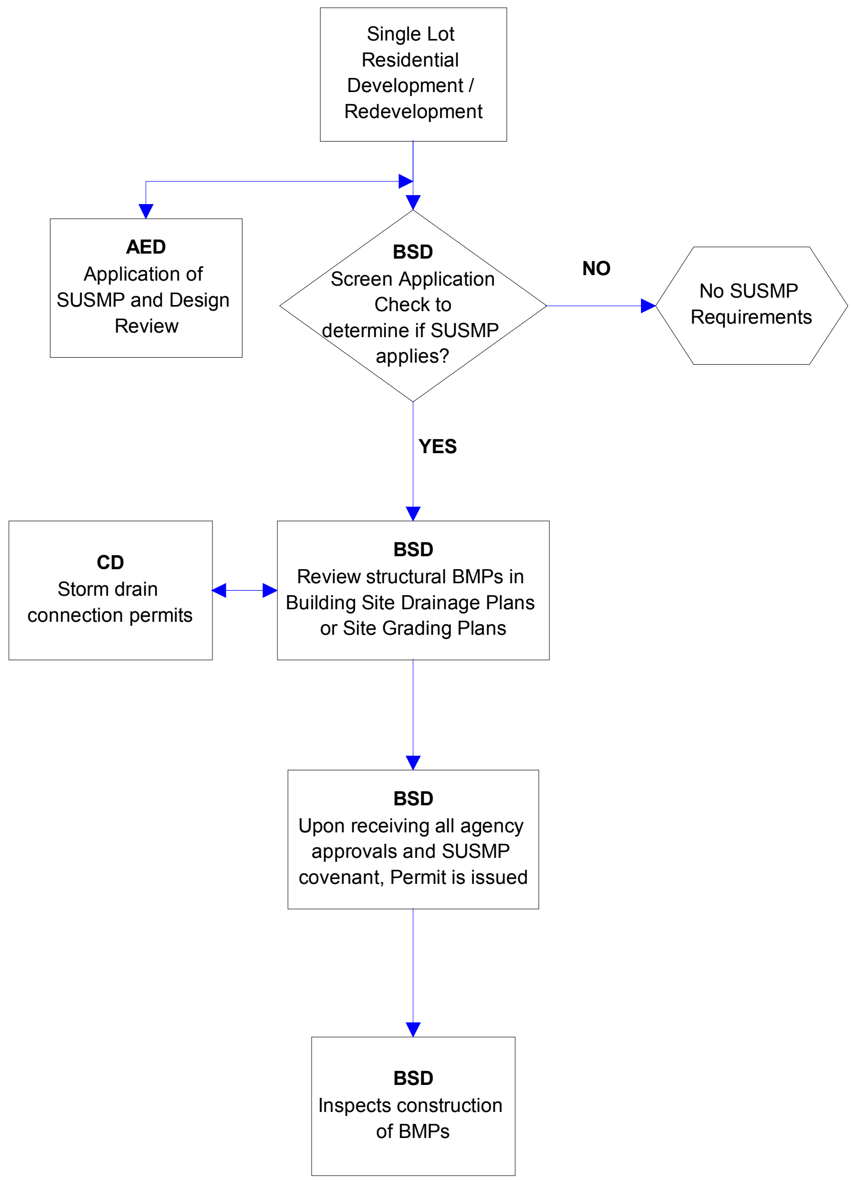
[5] "Hillside" means property located in an area with known erosive soil conditions, where the development contemplates grading on any natural slope that is 25% or greater and where grading contemplates cut or fill slopes. Single-family hillside homes are required to conserve natural areas, protect slopes and channels, provide storm drain system stenciling and signage, divert roof and surface flow runoff to vegetated areas before discharge unless the diversion would result in slope instability.

[6] "Redevelopment" means land-disturbing activity that results in the creation, addition, or replacement of 5,000 square feet or more of impervious surface area on an already developed site. Redevelopment includes, but is not limited to: the expansion of a building footprint; addition or replacement of a structure; replacement of impervious surface area that is not part of a routine maintenance activity; and land disturbing activities related to structural or impervious surfaces. It does not include routine maintenance to maintain

original line and grade, hydraulic capacity, or original purpose of facility, nor does it include emergency construction activities required to immediately protect public health and safety. Where redevelopment results in an increase of less than fifty percent of the impervious surfaces of a previously existing development, and the existing development was not subject to these SUSMPs, the Design Standards apply only to the addition, and not to the entire development.

Please refer to the following flow charts for your specific project permitting and inspection process.

FIGURE 2-1 PERMITTING AND INSPECTION OF SUSMP SINGLE LOT NON-SUBDIVISION RESIDENTIAL DEVELOPMENT / REDEVELOPMENT FLOWCHART



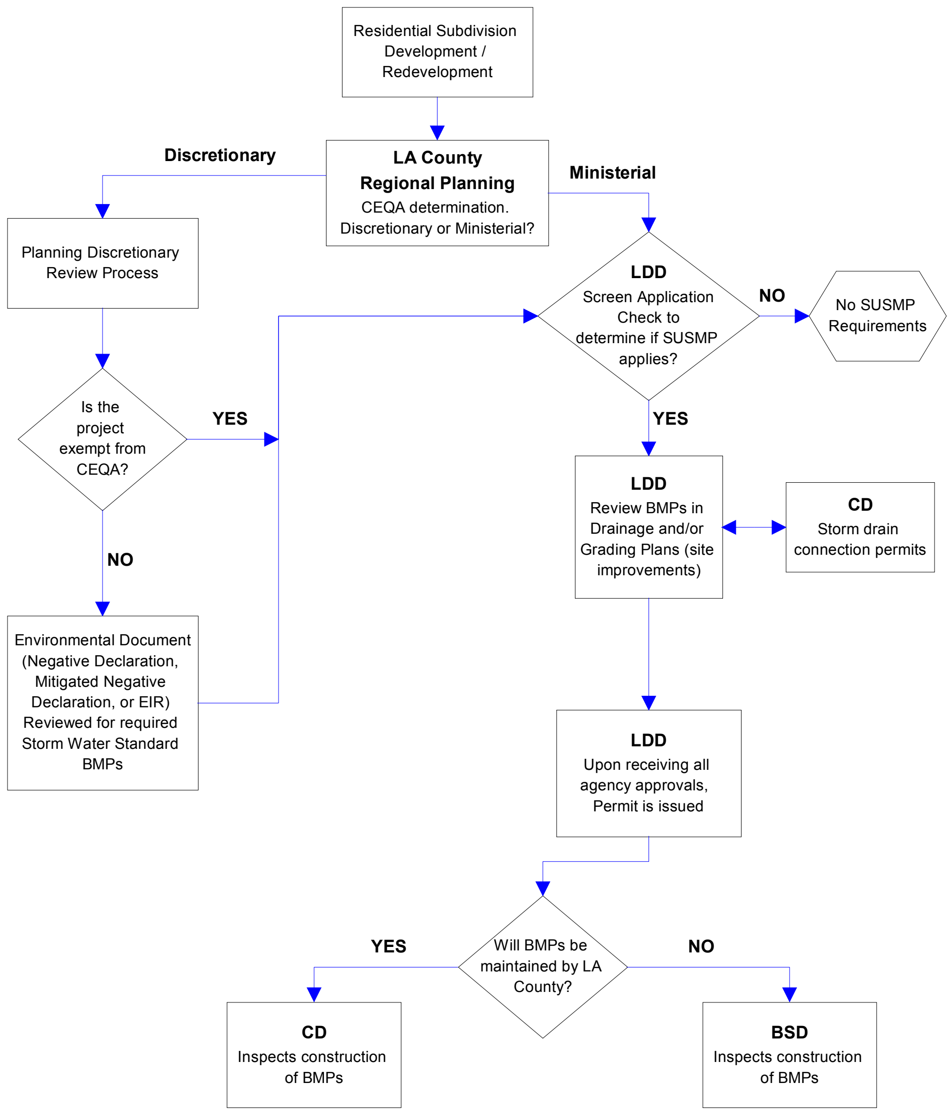
DEFINITIONS

AED- LACDPW Architectural Eng. Division

BSD- LACDPW Building & Safety Division

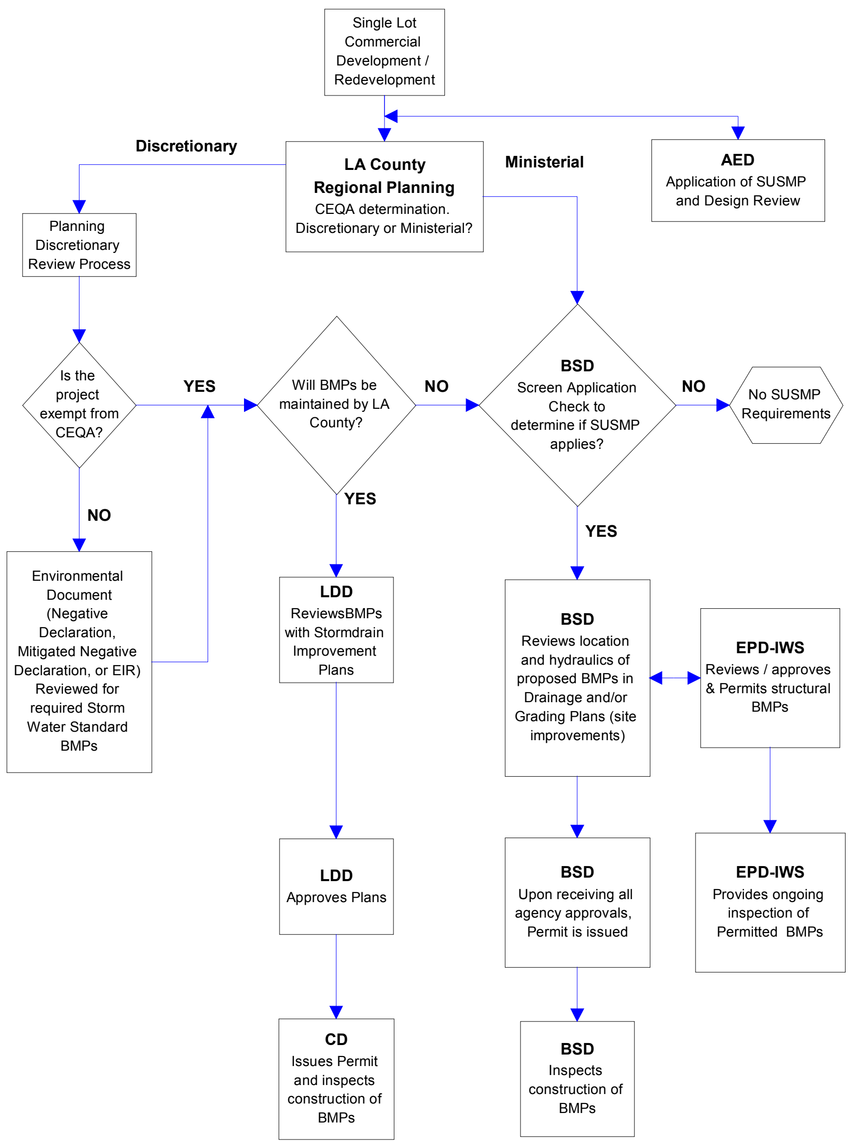
CD- LACDPW Construction Division

FIGURE 2-2 PERMITTING AND INSPECTION OF SUSMP RESIDENTIAL SUBDIVISION DEVELOPMENT / REDEVELOPMENT FLOWCHART



DEFINITIONS
BSD- LACDPW Building & Safety Division
CD- LACDPW Construction Division
LDD- LACDPW Land Development Division

FIGURE 2-3 PERMITTING AND INSPECTION OF SUSMP NON-SUBDIVISION RELATED COMMERCIAL DEVELOPMENT / REDEVELOPMENT FLOWCHART



DEFINITIONS

AED- LACDPW Architectural Eng. Division
BSD- LACDPW Building & Safety Division
CD- LACDPW Construction Division
LDD- LACDPW Land Development Division
EPD-IWS - LACDPW Environmental Programs Division, Industrial Waste Section

Section 3

STANDARD URBAN STORMWATER MITIGATION PLAN

STANDARD URBAN STORM WATER MITIGATION PLAN

FOR LOS ANGELES COUNTY AND CITIES IN LOS ANGELES COUNTY

LOS ANGELES COUNTY URBAN RUNOFF AND STORM WATER NPDES PERMIT

STANDARD URBAN STORM WATER MITIGATION PLAN

BACKGROUND

The municipal storm water National Pollutant Discharge Elimination System (NPDES) permit (Los Angeles County Permit) issued to Los Angeles County and 85 cities (Permittees) by the Los Angeles Regional Water Quality Control Board (Regional Board) on July 15, 1996, required the development and implementation of a program addressing storm water pollution issues in development planning for private projects. The same requirements are applicable to the City of Long Beach under its separate municipal storm water permit (City of Long Beach MS4 Permit), which was issued on June 30, 1999.

On December 13, 2001, the Regional Board issued a new NPDES Permit to the County of Los Angeles and 84 Permittees. The Program is being updated based on the 2001 Permit.

The requirement to implement a program for development planning is based on, federal and state statutes including: Section 402 (p) of the Clean Water Act, Section 6217 of the Coastal Zone Act Reauthorization Amendments (CZARA) of 1990, and the California Water Code. The Clean Water Act amendments of 1987 established a framework for regulating storm water discharges from municipal, industrial, and construction activities under the NPDES program. The primary objectives of the municipal storm water program requirements are to:

1. Effectively prohibit non-storm water discharges, and
2. Reduce the discharge of pollutants from storm water conveyance systems to the Maximum Extent Practicable (MEP) statutory standard.

The Standard Urban Storm Water Mitigation Plan (SUSMP) was developed as part of the municipal storm water program to address storm water pollution from new Development and Redevelopment by the private sector. This SUSMP contains a list of the minimum required Best Management Practices (BMPs) that must be used for a designated project. Additional BMPs may be required by ordinance or code adopted by the Permittee and applied generally or on a case by case basis. The Permittees are required to adopt the requirements set herein in their own SUSMP. Developers must incorporate appropriate SUSMP requirements into their project plans. Each Permittee will approve the project plan as part of the development plan approval process and prior to issuing building and grading permits for the projects covered by the SUSMP requirements.

All projects that fall into one of nine categories are identified in the 2001 Los Angeles County MS4 Permit as requiring SUSMPs. These categories are:

- Single-family hillside home (only development of one acre or more of surface area is subject to the SUSMP numerical design criteria requirement);
- Ten or more unit homes (including single family homes, multifamily homes, condominiums, and apartments);
- A 100,000 or more square feet of impervious surface area industrial/commercial developments;
- Automotive service facilities (SIC 5013, 5014, 5541, 7532-7534, and 7536-7539);
- Retail gasoline outlets;
- Restaurants (SIC 5812);
- Parking lots 5,000 square feet or more of surface area or with 25 or more parking spaces;
- Redevelopment projects in subject categories that meet Redevelopment thresholds; and
- Location within or directly adjacent to or discharging directly to an environmentally sensitive area.

The City of Long Beach permit requires SUSMP for the following categories only: (i) 10-99 home subdivisions; (ii) 100 or more subdivisions; (iii) 100,000 or more square foot commercial developments; and (iv) Projects located adjacent to or discharging to environmentally sensitive areas. For the remaining five categories, equivalent requirements have been included directly in the City of Long Beach Storm Water Management Plan.

Permittees shall have amended codes and ordinances, if necessary, not later than August 1, 2002, to give legal effect to the SUSMP requirements. The SUSMP requirements for projects identified herein took effect on September 2, 2002.

DEFINITIONS

"100,000 Square Foot Commercial Development" means any commercial development that creates at least 100,000 square feet of impermeable area, including parking areas."Automotive Repair Shop" means a facility that is categorized in any one of the following Standard Industrial Classification (SIC) codes: 5013, 5014, 5541, 7532-7534, or 7536-7539.

"Best Management Practice (BMP)" means methods, measures, or practices designed and selected to reduce or eliminate the discharge of pollutants to surface waters from point and nonpoint source discharge including storm water. BMPs include structural and nonstructural controls, and operation and maintenance procedures, which can be applied before, during, and/or after pollution producing activities.

"Commercial Development" means any development on private land that is not heavy industrial or residential. The category includes, but is not limited to: hospitals, laboratories and other medical facilities, educational institutions, recreational facilities, plant nurseries, multi-apartment buildings, car wash facilities, mini-malls and other business complexes, shopping malls, hotels, office buildings, public warehouses and other light industrial complexes.

“Directly Connected Impervious Area (DCIA)” means the area covered by a building, impermeable pavement, and/ or other impervious surfaces, which drains directly into the storm drain without first flowing across permeable land area (e.g. lawns).

“Environmentally Sensitive Area” means an area “in which plant or animal life or their habitats are either rare or especially valuable because of their special nature or role in an ecosystem and which would be easily disturbed or degraded by human activities and developments” (California Public Resources Code § 30107.5). Areas subject to storm water mitigation requirements are: areas designated as Significant Ecological by the County of Los Angeles (Los Angeles County Significant Areas Study, Los Angeles County Department of Regional Planning (1976) and amendments); an area designated as a Significant Natural Area by the California Department of Fish and Game’s Significant Natural Areas Program, provided that area has been field verified by the Department of Fish and Game; an area listed in the Basin Plan as supporting the "Rare, Threatened, or Endangered Species (RARE)" beneficial use; and an area identified by a Permittee as environmentally sensitive.

“Greater than (>) 9 unit home subdivision” means any subdivision being developed for 10 or more 10 single-family or multi-family dwelling units.

“Hillside” means property located in an area with known erosive soil conditions, where the development contemplates grading on any natural slope that is twenty-five percent or greater.

“Infiltration” means the downward entry of water into the surface of the soil.

“New Development” means land disturbing activities; structural development, including construction or installation of a building or structure, creation of impervious surfaces; and land subdivision.

“Parking Lot” means land area or facility for the parking or storage of motor vehicles used for business, commerce, industry, or personal use, with a lot size of 5,000 square feet or more of surface area, or with 25 or more parking spaces.

“Redevelopment” means a) land-disturbing activity that results in the creation, addition, or replacement of 5,000 square feet or more of impervious surface area on an already developed site. Where Redevelopment results in an alteration to more than fifty percent of impervious surfaces of a previously existing development, and the existing development was not subject to post development storm water quality control requirements, the entire project must be mitigated. Where Redevelopmet results in an alteration to less than fifty percent of impervious surfaces of a previously existing development, and the existing development was not subject to post development storm water quality control requirements, only the alteration must be mitigated, and not the entire development. b) Redevelopment does not include routine maintenance to maintain original line and grade, hydraulic capacity, or original purpose of facility, nor does it include emergency construction activities required to immediately protect public health and safety. c) Existing single-family structures are exempt from the Redevelopment requirements.

"Restaurant" means a facility that sells prepared foods and drinks for consumption, including stationary lunch counters and refreshment stands selling prepared foods and drinks for immediate consumption. (SIC code 5812).

"Retail Gasoline Outlet" means any facility engaged in selling gasoline and lubricating oils.

"Source Control BMP" means any schedules of activities, prohibitions of practices, maintenance procedures, managerial practices or operational practices that aim to prevent storm water pollution by reducing the potential for contamination at the source of pollution.

"Storm Event" means a rainfall event that produces more than 0.1 inch of precipitation and that, which is separated from the previous storm event by at least 72 hours of dry weather.

"Structural BMP" means any structural facility designed and constructed to mitigate the adverse impacts of storm water and urban runoff pollution (e.g. canopy, structural enclosure). The category may include both Treatment Control BMPs and Source Control BMPs.

"Treatment" means the application of engineered systems that use physical, chemical, or biological processes to remove pollutants. Such processes include, but are not limited to, filtration, gravity settling, media adsorption, biodegradation, biological uptake, chemical oxidation and UV radiation.

"Treatment Control BMP" means any engineered system designed to remove pollutants by simple gravity settling of particulate pollutants, filtration, biological uptake, media adsorption or any other physical, biological, or chemical process.

CONFLICTS WITH LOCAL PRACTICES

Where provisions of the SUSMP requirements conflict with established local codes, (e.g., specific language of signage used on storm drain stenciling), the Permittee may continue the local practice and modify the SUSMP to be consistent with the code, except that to the extent that the standards in the SUSMP are more stringent than those under local codes, such more stringent standards shall apply.

SUSMP PROVISIONS APPLICABLE TO ALL CATEGORIES

<u>REQUIREMENTS</u>

1. PEAK STORM WATER RUNOFF DISCHARGE RATES

Post-development peak storm water runoff discharge rates shall not exceed the estimated pre-development rate for developments where the increased peak storm water discharge rate will result in increased potential for downstream erosion.

2. CONSERVE NATURAL AREAS

If applicable, the following items are required and must be implemented in the site layout during the subdivision design and approval process, consistent with applicable General Plan and Local Area Plan policies:

- Concentrate or cluster Development on portions of a site while leaving the remaining land in a natural undisturbed condition.
- Limit clearing and grading of native vegetation at a site to the minimum amount needed to build lots, allow access, and provide fire protection.
- Maximize trees and other vegetation at each site by planting additional vegetation, clustering tree areas, and promoting the use of native and/or drought tolerant plants.
- Promote natural vegetation by using parking lot islands and other landscaped areas.
- Preserve riparian areas and wetlands.

3. MINIMIZE STORM WATER POLLUTANTS OF CONCERN

Storm water runoff from a site has the potential to contribute oil and grease, suspended solids, metals, gasoline, pesticides, and pathogens to the storm water conveyance system. The development must be designed so as to minimize, to the maximum extent practicable, the introduction of pollutants of concern that may result in significant impacts, generated from site runoff of directly connected impervious areas (DCIA), to the storm water conveyance system as approved by the building official. Pollutants of concern, consist of any pollutants that exhibit one or more of the following characteristics: current loadings or historic deposits of the pollutant are impacting the beneficial uses of a receiving water, elevated levels of the pollutant are found in sediments of a receiving water and/or have the potential to bioaccumulate in organisms therein, or the detectable inputs of the pollutant are at a concentrations or loads considered potentially toxic to humans and/or flora and fauna.

In meeting this specific requirement, “minimization of the pollutants of concern” will require the incorporation of a BMP or combination of BMPs best suited to maximize the reduction of pollutant loadings in that runoff to the Maximum Extent Practicable. Those BMPs best suited for that purpose are those listed in the *California Storm Water Best Management Practices Handbooks*; *Caltrans Storm Water Quality Handbook: Planning and Design Staff Guide*; *Manual for Storm Water Management in Washington State*; *The Maryland Stormwater Design Manual*; *Florida Development Manual: A Guide to Sound Land and Water Management*; Denver *Urban Storm Drainage Criteria Manual,* *Volume 3 – Best Management Practices* and *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters* , USEPA Report No. EPA-840-B-92-002, as "likely to have significant impact" beneficial to water quality for targeted pollutants that are of concern at the site in question. However, it is possible that a combination of BMPs not so designated, may in a particular circumstance, be better suited to maximize the reduction of the pollutants.

Examples of BMPs that can be used for minimizing the introduction of pollutants of concern generated from site runoff are identified in Table 2. Any BMP not specifically approved by the Regional Board in Resolution No. 99-03, "Approving Best Management Practices for Municipal Storm Water and Urban Runoff Programs in Los Angeles County", for development planning may be used if they have been recommended in one of the above references.

4. PROTECT SLOPES AND CHANNELS

Project plans must include BMPs consistent with local codes and ordinances and the SUSMP to decrease the potential of slopes and/or channels from eroding and impacting storm water runoff:

- Convey runoff safely from the tops of slopes and stabilize disturbed slopes.
- Utilize natural drainage systems to the maximum extent practicable
- Control or reduce or eliminate flow to natural drainage systems to the maximum extent practicable
- Stabilize permanent channel crossings.
- Vegetate slopes with native or drought tolerant vegetation.
- Install energy dissipaters, such as riprap, at the outlets of new storm drains, culverts, conduits, or channels that enter unlined channels in accordance with applicable specifications to minimize erosion, with the approval of all agencies with jurisdiction, e.g., the U.S. Army Corps of Engineers and the California Department of Fish and Game

5. PROVIDE STORM DRAIN SYSTEM STENCILING AND SIGNAGE

Storm drain stencils are highly visible source controls that are typically placed directly adjacent to storm drain inlets. The stencil contains a brief statement that prohibits the dumping of improper materials into the storm water conveyance system. Graphical icons, either illustrating anti-dumping symbols or images of receiving water fauna, are effective supplements to the anti-dumping message.

- All storm drain inlets and catch basins within the project area must be stenciled with prohibitive language (such as: "NO DUMPING – DRAINS TO OCEAN") and/or graphical icons to discourage illegal dumping.
- Signs and prohibitive language and/or graphical icons, which prohibit illegal

dumping, must be posted at public access points along channels and creeks within the project area.

- Legibility of stencils and signs must be maintained.

6. PROPERLY DESIGN OUTDOOR MATERIAL STORAGE AREAS

Outdoor material storage areas refer to storage areas or storage facilities solely for the storage of materials. Improper storage of materials outdoors may provide an opportunity for toxic compounds, oil and grease, heavy metals, nutrients, suspended solids, and other pollutants to enter the storm water conveyance system. Where proposed project plans include outdoor areas for storage of materials that may contribute pollutants to the storm water conveyance system, the following Structural or Treatment BMPs are required:

- Materials with the potential to contaminate storm water must be: (1) placed in an enclosure such as, but not limited to, a cabinet, shed, or similar structure that prevents contact with runoff or spillage to the storm water conveyance system; or (2) protected by secondary containment structures such as berms, dikes, or curbs.
- The storage area must be paved and sufficiently impervious to contain leaks and spills.
- The storage area must have a roof or awning to minimize collection of storm water within the secondary containment area.

7. PROPERLY DESIGN TRASH STORAGE AREAS

A trash storage area refers to an area where a trash receptacle or receptacles are located for use as a repository for solid wastes.

Loose trash and debris can be easily transported by the forces of water or wind into nearby storm drain inlets, channels, and/or creeks. All trash container areas must meet the following Structural or Treatment Control BMP requirements (individual single family residences are exempt from these requirements):

- Trash container areas must have drainage from adjoining roofs and pavement diverted around the area(s).

- Trash container areas must be screened or walled to prevent off-site transport of trash.

8. PROVIDE PROOF OF ONGOING BMP MAINTENANCE

Improper maintenance is one of the most common reasons why water quality controls will not function as designed or which may cause the system to fail entirely. It is important to consider who will be responsible for maintenance of a permanent BMP, and what equipment is required to perform the maintenance properly. As part of project review, if a project applicant has included or is required to include, Structural or Treatment Control BMPs in project plans, the Permittee shall require that the applicant provide verification of maintenance provisions through such means as may be appropriate, including, but not limited to legal agreements, covenants, CEQA mitigation requirements and/or Conditional Use Permits.

For all properties, the verification will include the developer's signed statement, as part of the project application, accepting responsibility for all structural and treatment control BMP maintenance until the time the property is transferred and, where applicable, a signed agreement from the public entity assuming responsibility for Structural or Treatment Control BMP maintenance. The transfer of property to a private or public owner must have conditions requiring the recipient to assume responsibility for maintenance of any Structural or Treatment Control BMP to be included in the sales or lease agreement for that property, and will be the owner's responsibility. The condition of transfer shall include a provision that the property owners conduct maintenance inspection of all Structural or Treatment Control BMPs at least once a year and retain proof of inspection. For residential properties where the Structural or Treatment Control BMPs are located within a common area which will be maintained by a homeowner's association, language regarding the responsibility for maintenance must be included in the projects conditions, covenants and restrictions (CC&Rs). Printed educational materials will be required to accompany the first deed transfer to highlight the existence of the requirement and to provide information on what storm water management facilities are present, signs that maintenance is needed, how the necessary maintenance can be performed, and assistance that the Permittee can provide. The transfer of this information shall also be required with any subsequent sale of the property.

If Structural or Treatment Control BMPs are located within a public area proposed for transfer, they will be the responsibility of the developer until they are accepted for transfer by the County or other appropriate public agency. Structural or Treatment Control BMPs proposed for transfer must meet design standards adopted by the public entity for the BMP installed and should be approved by the County or other appropriate public agency prior to its installation.

9. DESIGN STANDARDS FOR STRUCTURAL OR TREATMENT CONTROL BMPs

Structural or Treatment control BMPs selected for use at any of the following categories of planning development project shall meet the design standards of this Section unless specifically exempted:

a) Single-family hillside residential developments of one acre or more of surface area;

b) Housing developments (includes single family homes, multifamily homes, condominium, and apartments) of ten units or more;
c) A 100,000 square feet or more impervious surface area industrial/commercial development;
d) Automotive service facilities (SIC 5013, 5014, 5541, 7532-7534 and 7536-7538) [5,000 square feet or more of surface area];
e) Retail gasoline outlets [5,000 square feet or more impervious surface area and with projected Average Daily Traffic (ADT) of 100 or more vehicles]. Subsurface Treatment Control BMPs which may endanger public safety (i.e., create an explosive environment) are considered not appropriate;
f) Restaurants (SIC 5812) [5,000 square feet or more of surface area];
g) Parking lot 5,000 square feet or more of surface area or with 25 or more parking spaces;
h) Projects located in, adjacent to or discharging directly to an ESA that meet the following threshold conditions:
   (1) Discharge storm water and urban runoff that is likely to impact a sensitive biological species or habitat; and
   (2) Create 2,500 square feet or more of impervious surface area.
i) Redevelopment projects in subject categories that meet Redevelopment thresholds.

Post-construction Structural or Treatment Control BMPs shall be designed to:

A. Mitigate (infiltrate or treat) storm water runoff from either:

a) Volumetric Treatment Control BMP

(1) The 85th percentile 24-hour runoff event determined as the maximized capture storm water volume for the area, from the formula recommended in Urban Runoff Quality Management, WEF Manual of Practice No. 23/ ASCE Manual of Practice No. 87, (1998), or

(2) The volume of annual runoff based on unit basin storage water quality volume, to achieve 80 percent or more volume treatment by the method recommended in California Stormwater Best Management Practices Handbook – Industrial/ Commercial, (1993), or

(3) The volume of runoff produced from a 0.75 inch storm event, prior to its discharge to a storm water conveyance system, or

(4) The volume of runoff produced from a historical-record based reference 24-hour rainfall criterion for “treatment” (0.75 inch average for the Los Angeles County area) that achieves approximately the same reduction in pollutant loads achieved by the 85th percentile 24-hour runoff event.

Or

b) Flow Based Treatment Control BMP

(1) The flow of runoff produced from a rain event equal to at least 0.2 inches per hour intensity, or

(2) The flow of runoff produced from a rain event equal to at least two times the 85th percentile hourly rainfall intensity for Los Angeles County, or

(3) The flow of runoff produced from a rain event that will result in treatment of the same portion of runoff as treated using volumetric standards above.

AND

B. Control peak flow discharge to provide stream channel and over bank flood protection, based on flow design criteria selected by the local agency.

Limited Exclusion

Restaurants, where the land area for development or redevelopment is less than 5,000 square feet, are excluded from the numerical Structural or Treatment Control BMP design standard requirement only.

10. PROVISIONS APPLICABLE TO INDIVIDUAL PRIORITY PROJECT CATEGORIES

REQUIREMENTS

A. SINGLE-FAMILY HILLSIDE HOME

(1) Conserve natural areas;
(2) Protect slopes and channels;
(3) Provide storm drain system stenciling and signage;
(4) Divert roof runoff to vegetated areas before discharge unless the diversion would result in slope instability; and
(5) Direct surface flow to vegetated areas before discharge unless the diversion would result in slope instability

B. 100,000 SQUARE FEET INDUSTRIAL/COMMERCIAL DEVELOPMENTS

1. PROPERLY DESIGN LOADING/UNLOADING DOCK AREAS

Loading/unloading dock areas have the potential for material spills to be quickly transported to the storm water conveyance system. To minimize this potential, the following design criteria are required:

- Cover loading dock areas or design drainage to minimize run-on and runoff of storm water.
- Direct connections to storm drains from depressed loading docks (truck wells) are prohibited.

2. PROPERLY DESIGN REPAIR/MAINTENANCE BAYS

Oil and grease, solvents, car battery acid, coolant and gasoline from the repair/maintenance bays can negatively impact storm water if allowed to come into contact with storm water runoff. Therefore, design plans for repair bays must include the following:

- Repair/maintenance bays must be indoors or designed in such a way that do not allow storm water runon or contact with storm water runoff.
- Design a repair/maintenance bay drainage system to capture all washwater, leaks and spills. Connect drains to a sump for collection and disposal. Direct connection of the repair/maintenance bays to the storm drain system is prohibited. If required by local jurisdiction, obtain an Industrial Waste Discharge Permit.

3. PROPERLY DESIGN VEHICLE/EQUIPMENT WASH AREAS

The activity of vehicle/equipment washing/steam cleaning has the potential to contribute metals, oil and grease, solvents, phosphates, and suspended solids to the storm water conveyance system. Include in the project plans an area for washing/steam cleaning of vehicles and equipment. The area in the site design must be:

- Self-contained and/ or covered, equipped with a clarifier, or other pretreatment facility, and properly connected to a sanitary sewer.

C. RESTAURANTS

1. PROPERLY DESIGN EQUIPMENT/ACCESSORY WASH AREAS

The activity of outdoor equipment/accessory washing/steam cleaning has the potential to contribute metals, oil and grease, solvents, phosphates, and suspended solids to the storm water conveyance system. Include in the project plans an area for the washing/steam cleaning of equipment and accessories. This area must be:

- Self-contained, equipped with a grease trap, and properly connected to a sanitary sewer.
- If the wash area is to be located outdoors, it must be covered, paved, have secondary containment, and be connected to the sanitary sewer.

D. RETAIL GASOLINE OUTLETS

1. PROPERLY DESIGN FUELING AREA

Fueling areas have the potential to contribute oil and grease, solvents, car battery acid, coolant and gasoline to the storm water conveyance system. The project plans must include the following BMPs:

- The fuel dispensing area must be covered with an overhanging roof structure or canopy. The canopy's minimum dimensions must be equal to or greater than the area within the grade break. The canopy must not drain onto the fuel dispensing area, and the canopy downspouts must be routed to prevent drainage across the fueling area.
- The fuel dispensing area must be paved with Portland cement concrete (or equivalent smooth impervious surface), and the use of asphalt concrete shall be prohibited.
- The fuel dispensing area must have a 2% to 4% slope to prevent ponding, and must be separated from the rest of the site by a grade break that prevents run-on of storm water to the extent practicable.
- At a minimum, the concrete fuel dispensing area must extend 6.5 feet (2.0 meters) from the corner of each fuel dispenser, or the length at which the hose and nozzle assembly may be operated plus 1 foot (0.3 meter), whichever is less.

E. AUTOMOTIVE REPAIR SHOPS

1. PROPERLY DESIGN FUELING AREA

Fueling areas have the potential to contribute oil and grease, solvents, car battery acid, coolant and gasoline to the storm water conveyance system. Therefore, design plans, which include fueling areas, must contain the following:

- The fuel dispensing area should be covered with an overhanging roof structure or canopy. The cover's minimum dimensions must be equal to or greater than the area within the grade break. The cover must not drain onto the fuel dispensing area and the downspouts must be routed to prevent drainage across the fueling area.
- The fuel dispensing areas must be paved with Portland cement concrete (or equivalent smooth impervious surface), and the use of asphalt concrete shall be prohibited.
- The fuel dispensing area must have a 2% to 4% slope to prevent ponding, and must be separated from the rest of the site by a grade break that prevents run-on of storm water.
- At a minimum, the concrete fuel dispensing area must extend 6.5 feet (2.0 meters) from the corner of each fuel dispenser, or the length at which the hose and nozzle assembly may be operated plus 1 foot (0.3 meter), whichever is less.

2. PROPERLY DESIGN REPAIR/MAINTENANCE BAYS

Oil and grease, solvents, car battery acid, coolant and gasoline from the repair/maintenance bays can negatively impact storm water if allowed to come into contact with storm water runoff. Therefore, design plans for repair bays must include the following:

- Repair/maintenance bays must be indoors or designed in such a way that doesn't allow storm water run-on or contact with storm water runoff.
- Design a repair/maintenance bay drainage system to capture all wash-water, leaks and spills. Connect drains to a sump for collection and disposal. Direct connection of the repair/maintenance bays to the storm drain system is prohibited. If required by local jurisdiction, obtain an Industrial Waste Discharge Permit.

3. PROPERLY DESIGN VEHICLE/EQUIPMENT WASH AREAS

The activity of vehicle/equipment washing/steam cleaning has the potential to contribute metals, oil and grease, solvents, phosphates, and suspended solids to the storm water conveyance system. Include in the project plans an area for washing/steam cleaning of vehicles and equipment. This area must be:

- Self-contained and/or covered, equipped with a clarifier, or other pretreatment facility, and properly connected to a sanitary sewer or to a permitted disposal facility.

4. PROPERLY DESIGN LOADING/UNLOADING DOCK AREAS

Loading/unloading dock areas have the potential for material spills to be quickly transported to the storm water conveyance system. To minimize this potential, the following design criteria are required:

- Cover loading dock areas or design drainage to minimize run-on and runoff of storm water.
- Direct connections to storm drains from depressed loading docks (truck wells) are prohibited.

F. PARKING LOTS

1. PROPERLY DESIGN PARKING AREA

Parking lots contain pollutants such as heavy metals, oil and grease, and polycyclic aromatic hydrocarbons that are deposited on parking lot surfaces by motor-vehicles. These pollutants are directly transported to surface waters. To minimize the offsite transport of pollutants, the following design criteria are required:

- Reduce impervious land coverage of parking areas
- Infiltrate runoff before it reaches storm drain system.
- Treat runoff before it reaches storm drain system

2. PROPERLY DESIGN TO LIMIT OIL CONTAMINATION AND PERFORM MAINTENANCE

Parking lots may accumulate oil, grease, and water insoluble hydrocarbons from vehicle drippings and engine system leaks.

- Treat to remove oil and petroleum hydrocarbons at parking lots that are heavily used (e.g. fast food outlets, lots with 25 or more parking spaces , sports event parking lots, shopping malls, grocery stores, discount warehouse stores)
- Ensure adequate operation and maintenance of treatment systems particularly sludge and oil removal, and system fouling and plugging prevention control

11. WAIVER

A Permittee may, through adoption of an ordinance or code incorporating the treatment requirements of the SUSMP, provide for a waiver from the requirement if impracticability for a specific property can be established. A waiver of impracticability shall be granted only when all other Structural or Treatment Control BMPs have been considered and rejected as infeasible. Recognized situations of impracticability include, (i) extreme limitations of space for treatment on a redevelopment project, (ii) unfavorable or unstable soil conditions at a site to attempt infiltration, and (iii) risk of ground water contamination because a known unconfined aquifer lies beneath the land surface or an existing or potential underground source of drinking water is less than 10 feet from the soil surface. Any other justification for impracticability must be separately petitioned by the Permittee and submitted to the Regional Board for consideration. The Regional Board may consider approval of the waiver justification or may delegate the authority to approve a class of waiver justifications to the Regional Board Executive Officer. The supplementary waiver justification becomes recognized and effective only after approval by the Regional Board or the Regional Board Executive Officer. A waiver granted by a Permittee to any development or redevelopment project may be revoked by the Regional Board Executive Officer for cause and with proper notice upon petition.

12. MITIGATION FUNDING

The Permittees may propose a management framework, for endorsement by the Regional Board Executive Officer, to support regional or sub-regional solutions to storm water pollution, where any of the following situations occur:

a) A waiver for impracticability is granted
b) Legislative funds become available;
c) Off-site mitigation is required because of loss of environmental habitat; or
d) An approved watershed management plan or a regional storm water mitigation plan exists that incorporates an equivalent or improved strategy for storm water mitigation.

13. LIMITATION ON USE OF INFILTRATION BMPs

Three factors significantly influence the potential for storm water to contaminate ground water. They are (i) pollutant mobility, (ii) pollutant abundance in storm water, (iii) and soluble fraction of pollutant. The risk of contamination of groundwater may be reduced by pretreatment of storm water. A discussion of limitations and guidance for infiltration practices is contained in, *Potential Groundwater Contamination from Intentional and Non-Intentional Stormwater Infiltration, Report No. EPA/600/R-94/051, USEPA (1994).*

In addition, the distance of the groundwater table from the infiltration BMP may also be a factor determining the risk of contamination. A water table distance separation of ten feet depth in California presumptively poses negligible risk for storm water not associated with industrial activity or high vehicular traffic.

Infiltration BMPs are not recommended for areas of industrial activity or areas subject to high vehicular traffic (25,000 or greater average daily traffic (ADT) on main roadway or 15,000 or more ADT on any intersecting roadway) unless appropriate pretreatment is provided to ensure groundwater is protected and the infiltration BMP is not rendered ineffective by overload.

14. ALTERNATIVE CERTIFICATION FOR STORM WATER TREATMENT MITIGATION

In lieu of conducting detailed BMP review to verify Structural or Treatment Control BMPs adequacy, a Permittee may elect to accept a signed certification from a Civil Engineer or a Licensed Architect registered in the State of California, that the plan meets the criteria established herein. The Permittee is encouraged to verify that certifying person(s) have been trained on BMP design for water quality, not more than two years prior to the signature date. Training conducted by an organization with storm water BMP design expertise (e.g., a University, American Society of Civil Engineers, American Society of Landscape Architects, American Public Works Association, or the California Water Environment Association) may be considered qualifying.

15. RESOURCES AND REFERENCE

TABLE 3-1

SUGGESTED RESOURCES	HOW TO GET A COPY
Start at the Source (1999) by Bay Area Stormwater Management Agencies Association Detailed discussion of permeable pavements and alternative driveway designs presented.	Bay Area Stormwater Management Agencies Association 2101 Webster Street Suite 500 Oakland, CA 510-286-1255
Design of Stormwater Filtering Systems (1996) by Richard A. Claytor and Thomas R. Schuler Presents detailed engineering guidance on ten different storm water-filtering systems.	Center for Watershed Protection 8391 Main Street Ellicott City, MD 21043 410-461-8323

Better Site Design: A Handbook for Changing Development Rules in Your Community (1998) Presents guidance for different model development alternatives.	Center for Watershed Protection 8391 Main Street Ellicott City, MD 21043 410-461-8323
Design Manual for Use of Bioretention in Stormwater Management (1993) Presents guidance for designing bioretention facilities.	Prince George's County Watershed Protection Branch 9400 Peppercorn Place, Suite 600 Landover, MD 20785
Operation, Maintenance and Management of Stormwater Management (1997) Provides a thorough look at stormwater practices including, planning and design considerations, programmatic and regulatory aspects, maintenance considerations, and costs.	Watershed Management Institute, Inc. 410 White Oak Drive Crawfordville, FL 32327 850-926-5310
California Storm Water Best Management Practices Handbooks (1993) for Construction Activity, Municipal, and Industrial/Commercial Presents a description of a large variety of Structural BMPs, Treatment Control, BMPs and Source Control BMPs	Los Angeles County Department of Public Works Cashiers Office 900 S. Fremont Avenue Alhambra, CA 91803 626-458-6959
Second Nature: Adapting LA's Landscape for Sustainable Living (1999) by Tree People Detailed discussion of BMP designs presented to conserve water, improve water quality, and achieve flood protection.	Tree People 12601 Mullholland Drive Beverly Hills, CA 90210 818-753-4600 (?)
Florida Development Manual: A Guide to Sound Land and Water Management (1988) Presents detailed guidance for designing BMPs	Florida Department of the Environment 2600 Blairstone Road, Mail Station 3570 Tallahassee, FL 32399 850-921-9472
Stormwater Management in Washington State (1999) Vols. 1-5 Presents detailed guidance on BMP design for new development and construction.	Department of Printing State of Washington Department of Ecology P.O. Box 798 Olympia, WA 98507-0798 360-407-7529
Maryland Stormwater Design Manual (1999) Presents guidance for designing storm water BMPs	Maryland Department of the Environment 2500 Broening Highway Baltimore, MD 21224 410-631-3000

Texas Nonpoint Source Book – Online Module (1998)www.txnpsbook.org Presents BMP design and guidance information on-line	Texas Statewide Storm Water Quality Task Force North Central Texas Council of Governments 616 Six Flags Drive Arlington, TX 76005 817-695-9150
Urban Storm Drainage, Criteria Manual – Volume 3, Best Management Practices (1999) Presents guidance for designing BMPs	Urban Drainage and Flood Control District 2480 West 26th Avenue, Suite 156-B Denver, CO 80211 303-455-6277
Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters (1993) Report No. EPA–840-B-92-002. Provides an overview of, planning and design considerations, programmatic and regulatory aspects, maintenance considerations, and costs.	National Technical Information Service U.S. Department of Commerce Springfield, VA 22161 800-553-6847
National Stormwater Best Management Practices (BMP) Database, Version 1.0 Provides data on performance and evaluation of storm water BMPs	American Society of Civil Engineers 1801 Alexander Bell Drive Reston, VA 20191 703-296-6000
Caltrans Storm Water Quality Handbook: Planning and Design Staff Guide (Best Management Practices Handbooks (1998) Presents guidance for design of storm water BMPs	California Department of Transportation P.O. Box 942874 Sacramento, CA 94274-0001 916-653-2975

TABLE 3-2

EXAMPLE BEST MANAGEMENT PRACTICES (BMPs)

The following are examples of BMPs that can be used for minimizing the introduction of pollutants of concern that may result in significant impacts, generated from site runoff to the storm water conveyance system. (See Table 1: Suggested Resources for additional sources of information):

- Provide reduced width sidewalks and incorporate landscaped buffer areas between sidewalks and streets. However, sidewalk widths must still comply with regulations for the Americans with Disabilities Act and other life safety requirements.
- Design residential streets for the minimum required pavement widths needed to comply with all zoning and applicable ordinances to support travel lanes; on-street parking; emergency, maintenance, and service vehicle access; sidewalks; and vegetated open channels.
- Comply with all zoning and applicable ordinances to minimize the number of residential street cul-de-sacs and incorporate landscaped areas to reduce their impervious cover. The radius of cul-de-sacs should be the minimum required to accommodate emergency and maintenance vehicles. Alternative turnarounds should be considered.
- Use permeable materials for private sidewalks, driveways, parking lots, or interior roadway surfaces (examples: hybrid lots, parking groves, permeable overflow parking, etc.).
- Use open space development that incorporates smaller lot sizes.
- Reduce building density.
- Comply with all zoning and applicable ordinances to reduce overall lot imperviousness by promoting alternative driveway surfaces and shared driveways that connect two or more homes together.
- Comply with all zoning and applicable ordinances to reduce the overall imperviousness associated with parking lots by providing compact car spaces, minimizing stall dimensions, incorporating efficient parking lanes, and using pervious materials in spillover parking areas.
- Direct rooftop runoff to pervious areas such as yards, open channels, or vegetated areas, and avoid routing rooftop runoff to the roadway or the storm water conveyance system.
- Vegetated swales and strips
- Extended/dry detention basins
- Infiltration basin
- Infiltration trenches
- Wet ponds
- Constructed wetlands
- Oil/Water separators
- Catch basin inserts
- Continuous flow deflection/ separation systems
- Storm drain inserts
- Media filtration
- Bioretention facility
- Dry-wells
- Cisterns
- Foundation planting
- Catch basin screens
- Normal flow storage/ separation systems
- Clarifiers
- Filtration systems
- Primary waste water treatment systems

TABLE 3-3

HABITAT PROTECTION IN THE LOS ANGELES COUNTY AREA

Agency:
Los Angeles County Department of Regional Planning

Designation:
Significant Ecological Areas (SEA)

Definitions:
Significant Ecological Areas (SEAs) are areas that have been identified by the Los Angeles County General Plan as containing unique or unusual species assemblages, or areas of habitat that are rapidly declining in the Los Angeles County. The SEAs were established to protect a special or sometimes unique collection of habitats and species from loss due to encroachment and human disturbances. However, SEAs are not intended to function as isolated preservation areas.

Affected Areas:
(See Figure 1)

Agency:
Los Angeles Regional Water Quality Control Board

Designation:
Rare, Threatened, or Endangered Species (RARE)

Definitions:
An area listed in the Los Angeles Basin Plan as supporting the "RARE, Threatened, or Endangered Species (RARE)" beneficial use.

Affected Areas:
(See Table 3A)

Agency:
California Department of Fish & Game

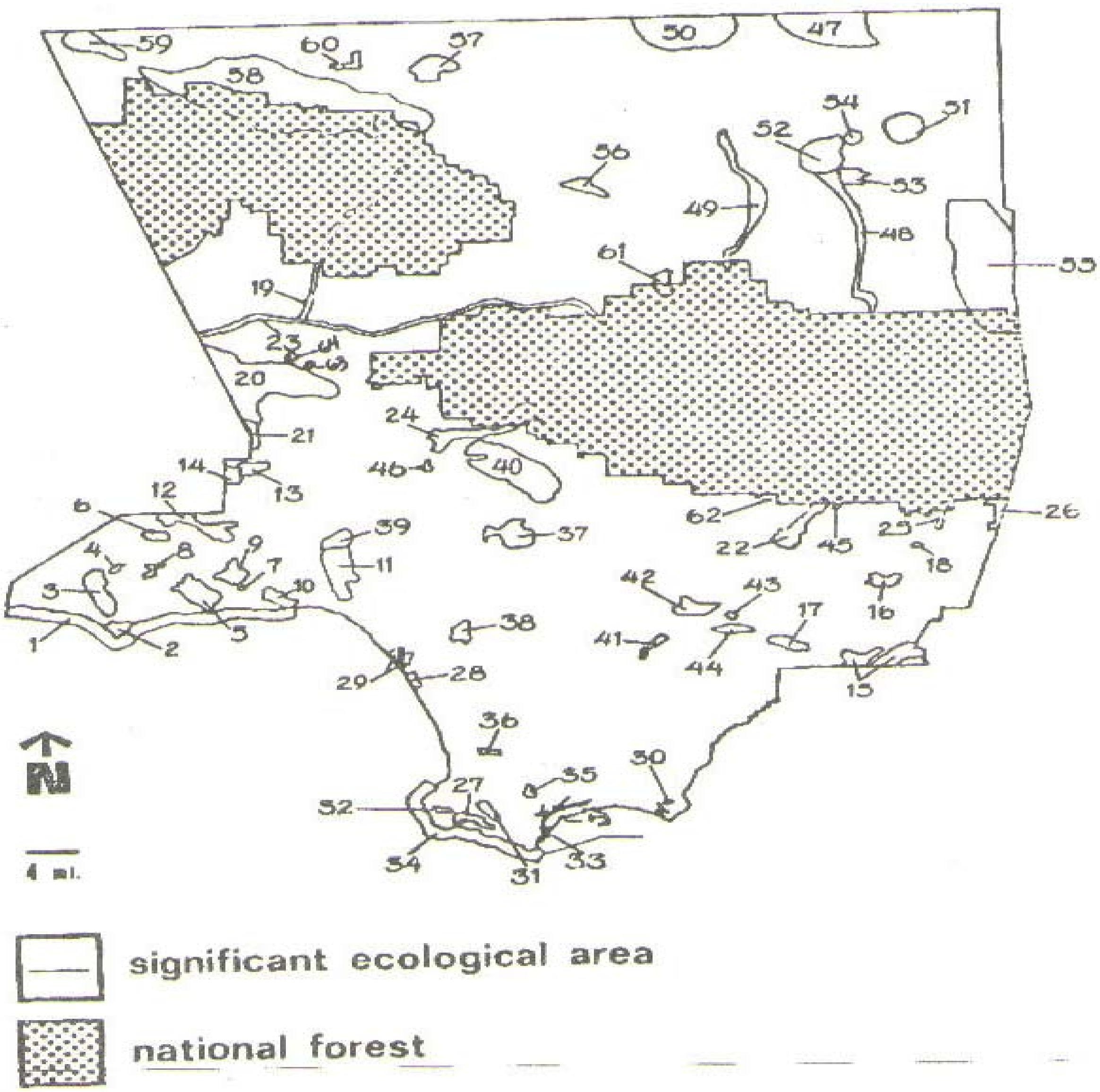
Designation:
Significant Natural Area

Definition:
An area designated by the California Department of Fish and Game's Significant Natural Areas Progra.

Affected Area:
N/A

FIGURE 1

SIGNIFICANT ECOLOGICAL AREAS IN LOS ANGELES COUNTY



APPENDIX A

VOLUME AND FLOW RATE CALCULATIONS

APPENDIX A VOLUME & FLOW RATE CALCULATIONS

A.1 METHOD FOR CALCULATING STANDARD URBAN STORMWATER MITIGATION PLAN FLOW RATES AND VOLUMES BASED ON 0.75-INCHES OF RAINFALL: WORKSHEET

PROJECT NAME

____

NOMENCLATURE

A_I	=	Impervious Area (acres)
A_P	=	Pervious Area (acres)
A_U	=	Contributing Undeveloped Upstream Area (acres)
A_{Total}	=	Total Area of Development and Contributing Undeveloped Upstream Area (acres)
C_D	=	Developed Runoff Coefficient
C_U	=	Undeveloped Runoff Coefficient
I_X	=	Rainfall Intensity (inches / hour)
Q_{PM}	=	Peak Mitigation Flow Rate (cfs)
T_C	=	Time of Concentration (minutes, must be between 5-30 min.)
V_M	=	Mitigation Volume (ft^3)

EQUATIONS

$$A_{Total} = A_I + A_P + A_U$$
$$A_I = (A_{Total} \ * \ \text{% of Development which is Impervious})$$
$$A_P = (A_{Total} \ * \ \text{% of Development which is Pervious})$$
$$A_U = (A_{Total} \ * \ \text{% of Contributing Undeveloped Upstream Area***})$$

$$C_D = (\,0.9 * \text{Imp.}\,) + [\,(\,1.0 - \text{Imp.}\,) * C_U\,] \qquad \text{If } C_D < C_U\text{, use } C_D = C_U$$

$$Q_{PM} = C_D * I_X * A_{Total} * (\text{ 1 hour / 3,600 seconds}) * (\text{1 ft / 12 inches}) * (43{,}560\ ft^2 / \text{1 acre})$$
$$= C_D * I_X * A_{Total} * (1.008333\ ft^3\text{-hour / acre-inches-seconds})$$

$$T_C = 10^{-0.507} * (\,C_D * I_X\,)^{-0.519} * \text{Length}^{0.483} * \text{Slope}^{-0.135}$$

$$V_M = (\text{0.75 inches}) * [(\,A_I\,)(\,0.9\,) + (A_P + A_U)(\,C_U\,)] * (\text{1 ft / 12 inches}) * (43{,}560\ ft^2 / \text{1 acre})$$
$$= (\,2{,}722.5\ ft^3 / \text{acre}\,) * [\,(\,A_I\,)(\,0.9\,) + (\,A_P + A_U\,)(\,C_U\,)\,]$$

***** Contributing Undeveloped Upstream Area is an area where stormwater runoff from an undeveloped upstream area will flow directly or indirectly to the Post-Construction Best Management Practices (BMPs) proposed for the development. This additional flow must be included in the flow rate and volume calculations to appropriately size the BMPs.**

PROVIDE PROPOSED PROJECT CHARACTERISTICS

A_{Total} ________________ Acres

Type of Development ________________

Predominate Soil Type # ________________

% of Project Impervious ________________

% of Project Pervious ________________

% of Project Contributing
Undeveloped Area ________________

A_I ________________ Acres

A_P ________________ Acres

A_U ________________ Acres

DETERMINING THE PEAK MITIGATED FLOW RATE (Q_{PM}):

In order to determine the peak mitigated flow rate (Q_{PM}) from the new development, use the Los Angeles County Department of Public Works *Hydrology Manual*. Use the Modified Rational Method for calculating the peak mitigation Q_{PM} for compliance with the Standard Urban Stormwater Mitigation Plan (SUSMP). Use attached **Table 1** for all maximum intensity (I_X) values used.

By trial and error, determine the time of concentration (T_C), as shown below:

CALCULATION STEPS:

1. Assume an initial T_C value between 5 and 30 minutes.

T_C __________ minutes

2. Using Table 1, look up the assumed T_C value and select the corresponding I_X intensity in inches/hour.

I_X __________ inches/hour

3. Determine the value for the Undeveloped Runoff Coefficient, C_U, using the runoff coefficient curve corresponding to the predominant soil type.

C_U __________

4. Calculate the Developed Runoff Coefficient, $C_D = (0.9 * \text{Imp.}) + [(1.0 - \text{Imp.}) * C_U]$

C_D __________

5. Calculate the value for $C_D * I_X$

$C_D * I_X$ __________

6. Calculate the time of concentration, $T_C = 10^{-0.507} * (C_D * I_X)^{-0.519} * \text{Length}^{0.483} * \text{Slope}^{-0.135}$

Calculated T_C __________ minutes

7. Calculate the difference between the initially assumed T_C and the calculated T_C, if the difference is greater than 0.5 minutes. Use the calculated T_C as the assumed initial T_C in the second iteration. If the T_C value is within 0.5 minutes, round the acceptable T_C value to the nearest minute.

TABLE FOR ITERATIONS:

Iteration No.	**Initial T_C (min)**	**I_X (in/hr)**	**C_U**	**C_D**	**C_D*I_X (in/hr)**	**Calculated T_C (min)**	**Difference (min)**
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

Acceptable T_C value _____________ minutes

8. Calculate the Peak Mitigation Flow Rate,
   $Q_{PM} = C_D * I_X * A_{Total} * (1.008333\ ft^3\text{-hour / acre-inches-seconds})$

Q_{PM} __________ cfs

TABLE 1

INTENSITY - DURATION DATA FOR 0.75-INCHES OF RAINFALL
FOR ALL RAINFALL ZONES

Duration, T_C (min)	Rainfall Intensity, I_X (in/hr)
5	0.447
6	0.411
7	0.382
8	0.359
9	0.339
10	0.323
11	0.309
12	0.297
13	0.286
14	0.276
15	0.267
16	0.259
17	0.252
18	0.245
19	0.239
20	0.233
21	0.228
22	0.223
23	0.218
24	0.214
25	0.210
26	0.206
27	0.203
28	0.199
29	0.196
30	0.193

DETERMINING THE VOLUME (V_M)

In order to determine the volume (V_M) of stormwater runoff to be mitigated from the new development, use the following equation:

$$V_M = (2{,}722.5 \text{ ft}^3 / \text{acre}) * [(A_I)(0.9) + (A_P + A_U)(C_U)]$$

A.2 FLOW RATE AND VOLUME CALCULATION EXAMPLE

PROJECT NAME

Industrial Site Example

NOMENCLATURE

A_I = Impervious Area (acres)
A_P = Pervious Area (acres)
A_U = Contributing Undeveloped Upstream Area (acres)
A_{Total} = Total Area of Development and Contributing Undeveloped Upstream Area (acres)
C_D = Developed Runoff Coefficient
C_U = Undeveloped Runoff Coefficient
I_X = Rainfall Intensity (inches / hour)
Q_{PM} = Peak Mitigation Flow Rate (cfs)
T_C = Time of Concentration (minutes, must be between 5-30 min.)
V_M = Mitigation Volume (ft^3)

EQUATIONS

$A_{Total} = A_I + A_P + A_U$
$A_I = (A_{Total}$ * % of Development which is Impervious)
$A_P = (A_{Total}$ * % of Development which is Pervious)
$A_U = (A_{Total}$ * % of Contributing Undeveloped Upstream Area***)

$C_D = (0.9 * \text{Imp.}) + [(1.0 - \text{Imp.}) * C_U]$ If $C_D < C_U$, use $C_D = C_U$

$Q_{PM} = C_D * I_X * A_{Total} * (1 \text{ hour} / 3{,}600 \text{ seconds}) * (1 \text{ ft} / 12 \text{ inches}) * (43{,}560 \text{ ft}^2 / 1 \text{ acre})$
$= C_D * I_X * A_{Total} * (1.008333 \text{ ft}^3\text{-hour / acre-inches-seconds})$

$T_C = 10^{-0.507} * (C_D * I_X)^{-0.519} * \text{Length}^{0.483} * \text{Slope}^{-0.135}$

$V_M = (0.75 \text{ inches}) * [(A_I)(0.9) + (A_P + A_U)(C_U)] * (1 \text{ ft} / 12 \text{ inches}) * (43{,}560 \text{ ft}^2 / 1 \text{ acre})$
$= (2{,}722.5 \text{ ft}^3 / \text{acre}) * [(A_I)(0.9) + (A_P + A_U)(C_U)]$

***** Contributing Undeveloped Upstream Area is an area where stormwater runoff from an undeveloped upstream area will flow directly or indirectly to the Post-Construction Best Management Practices (BMPs) proposed for the development. This additional flow must be included in the flow rate and volume calculations to appropriately size the BMPs.**

PROVIDE PROPOSED PROJECT CHARACTERISTICS

A_{Total}	**5.51**	Acres
Type of Development	**Industrial**	
Predominate Soil Type #	**6**	
% of Project Impervious	**91%**	
% of Project Pervious	**9%**	
% of Project Contributing Undeveloped Area	**0%**	
A_I	**5.0141**	Acres
A_P	**0.4959**	Acres
A_U	**0**	Acres

DETERMINING THE PEAK MITIGATED FLOW RATE (Q_{PM}):

In order to determine the peak mitigated flow rate (Q_{PM}) from the new development, use the Los Angeles County Department of Public Works *Hydrology Manual*. Use the Modified Rational Method for calculating the peak mitigation Q_{PM} for compliance with the Standard Urban Stormwater Mitigation Plan (SUSMP). Use attached **Table 1** for all maximum intensity (I_X) values used.

By trial and error, determine the time of concentration (T_C), as shown below:

<u>CALCULATION STEPS</u>:

1. Assume an initial T_C value between 5 and 30 minutes.

T_C **15** minutes

2. Using Table 1, look up the assumed T_C value and select the corresponding I_X intensity in inches/hour.

I_X **0.267** inches/hour

3. Determine the value for the Undeveloped Runoff Coefficient, C_U, using the runoff coefficient curve corresponding to the predominant soil type.

C_U **0.1**

4. Calculate the Developed Runoff Coefficient, $C_D = (0.9 * \text{Imp.}) + [(1.0 - \text{Imp.}) * C_U]$

C_D **0.828**

5. Calculate the value for $C_D * I_X$

$C_D * I_X$ **0.221076**

6. Calculate the time of concentration, $T_C = 10^{-0.507} * (C_D * I_X)^{-0.519} * \text{Length}^{0.483} * \text{Slope}^{-0.135}$

Calculated T_C **28.26** minutes

7. Calculate the difference between the initially assumed T_C and the calculated T_C, if the difference is greater than 0.5 minutes. Use the calculated T_C as the assumed initial T_C in the second iteration. If the T_C value is within 0.5 minutes, round the acceptable T_C value to the nearest minute.

TABLE FOR ITERATIONS:

Iteration No.	Initial T_C (min)	I_X (in/hr)	C_U	C_D	C_D*I_X (in/hr)	Calculated T_C (min)	Difference (min)
1	**15**	**0.267**	**0.1**	**0.828**	**0.221076**	**28.26**	**13.26**
2	**28.26**	**0.198**	**0.1**	**0.828**	**0.163944**	**33.01**	**4.75**
3	**33.01**	**n/a**					
4							
5							
6							
7							
8							
9							
10							

Acceptable T_C value **30** minutes

8. Calculate the Peak Mitigation Flow Rate,
   $Q_{PM} = C_D * I_X * A_{Total} * (1.008333\ ft^3\text{-hour / acre-inches-seconds})$

Q_{PM} **0.89** cfs

$\boxed{\mathbf{Q_{PM} = 0.89\ cfs}}$

C_D = 0.828
I_{30} = 0.193
A_{Total} = 5.51 acres

Use I_{30} since T_c is greater than 30 minutes.

TABLE 1

INTENSITY - DURATION DATA FOR 0.75-INCHES OF RAINFALL
FOR ALL RAINFALL ZONES

Duration, T_C (min)	Rainfall Intensity, I_X (in/hr)
5	0.447
6	0.411
7	0.382
8	0.359
9	0.339
10	0.323
11	0.309
12	0.297
13	0.286
14	0.276
Iteration #1 ➔ 15	0.267
16	0.259
17	0.252
18	0.245
19	0.239
20	0.233
21	0.228
22	0.223
23	0.218
24	0.214
25	0.210
26	0.206
27	0.203
Iteration #2 ➔ 28	0.199 Approx. ~0.198
29	0.196
30	0.193

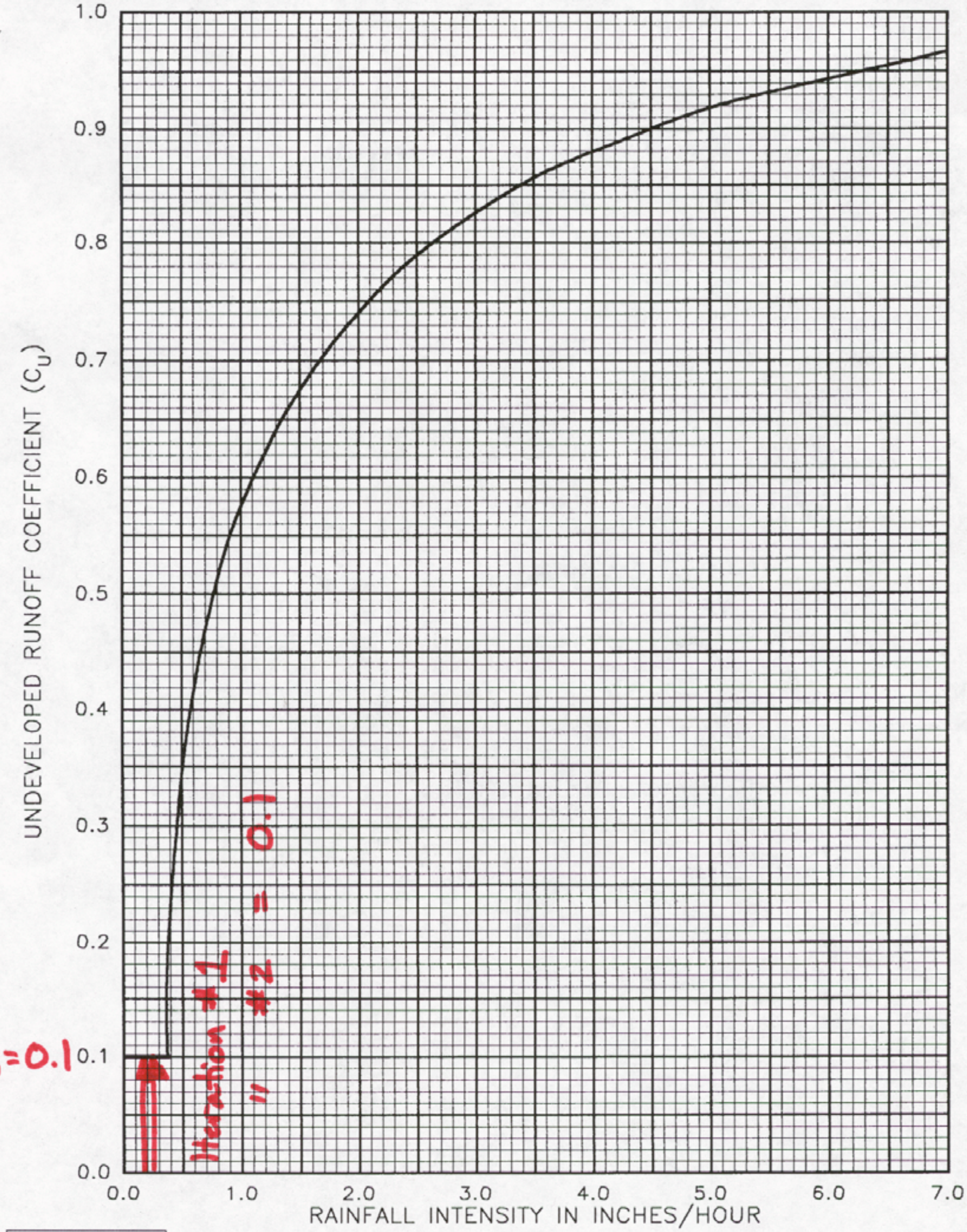
DETERMINING THE VOLUME (V_M)

In order to determine the volume (V_M) of stormwater runoff to be mitigated from the new development, use the following equation:

$$V_M = (2{,}722.5 \text{ ft}^3 / \text{acre}) * [(A_I)(0.9) + (A_P + A_U)(C_U)]$$

A_I = 5.0141 acres
A_P = 0.4959 acres
C_U = 0.1

$$\boxed{V_M = 12{,}420 \text{ ft}^3}$$



Equation:
$C_D = (0.9 * IMP) + (1.0 - IMP)\ C_U$
Where: C_D = Developed runoff coefficient. IMP = Proportion impervious. C_U = Undeveloped runoff coefficient.

Los Angeles County
Department of Public Works

RUNOFF COEFFICIENT CURVE
SOIL TYPE NO. 006

NS006.SPG

Hydrology/Sedimentation Appendix D-25 December 1990

APPENDIX B

BMP DESIGN CRITERIA

APPENDIX B BMP DESIGN CRITERIA

B.1 BIORETENTION FACILITY

DESCRIPTION

Bioretention is a best management practice (BMP) developed in the early 1990's by the Prince George's County, MD, Department of Environmental Resources (PGDER). Bioretention utilizes soils and both woody and herbaceous plants to remove pollutants from stormwater runoff. As shown in Figure 1, runoff is conveyed as sheet flow to the treatment area, which consists of a grass buffer strip, sand bed, ponding area, organic layer or mulch layer, planting soil, and plants. Runoff passes first over or through a sand bed, which slows the runoff's velocity, distributes it evenly along the length of the ponding area, which consists of a surface organic layer and/or ground cover and the underlying planting soil. The ponding area is graded; its center depressed. Water is ponded to a depth of 6 inches and gradually infiltrates the bioretention area and/or is evapotranspired. Bioretention areas are applicable as on-lot retention facilities that are designed to mimic forested systems that naturally control hydrology. The bioretention area is graded to drain excess runoff over a weir and into the storm drain system. Stored water in the bioretention area planting soil infiltrates over a period of days into the underlying soils.

The basic bioretention design shown in Figure 1 can be modified to accommodate more specific needs. The bioretention BMP design can be modified to include an underdrain within the sand bed to collect the infiltrated water and discharge it to a downstream storm drain system. This modification may be required when impervious subsoils and marine clays prevent complete infiltration in the soil system. This modified design makes the bioretention area act more as a filter that discharges treated water than as an infiltration device.

There are six basic components of a bioretention facility:

(1) Grass Buffer Strip	-	Designed to filter out particulates and reduce runoff velocity.
(2) Sand Bed	-	Further reduces velocity by capturing a portion of the runoff and distributes it evenly along the length of the ponding area. Also provides aeration to the plant bed and enhances infiltration.
(3) Ponding Area	-	Collects and stores runoff prior to infiltration.
(4) Organic/Mulch Layer	-	Provides some filtering of runoff, encourages development of beneficial microorganisms, and protects the soil surface from erosion.
(5) Planting Soil	-	Provides nourishment for the plant life. Clay particles within the soil also remove certain pollutants through

		adsorption.
(6) Plants	-	Provides uptake of harmful pollutants.

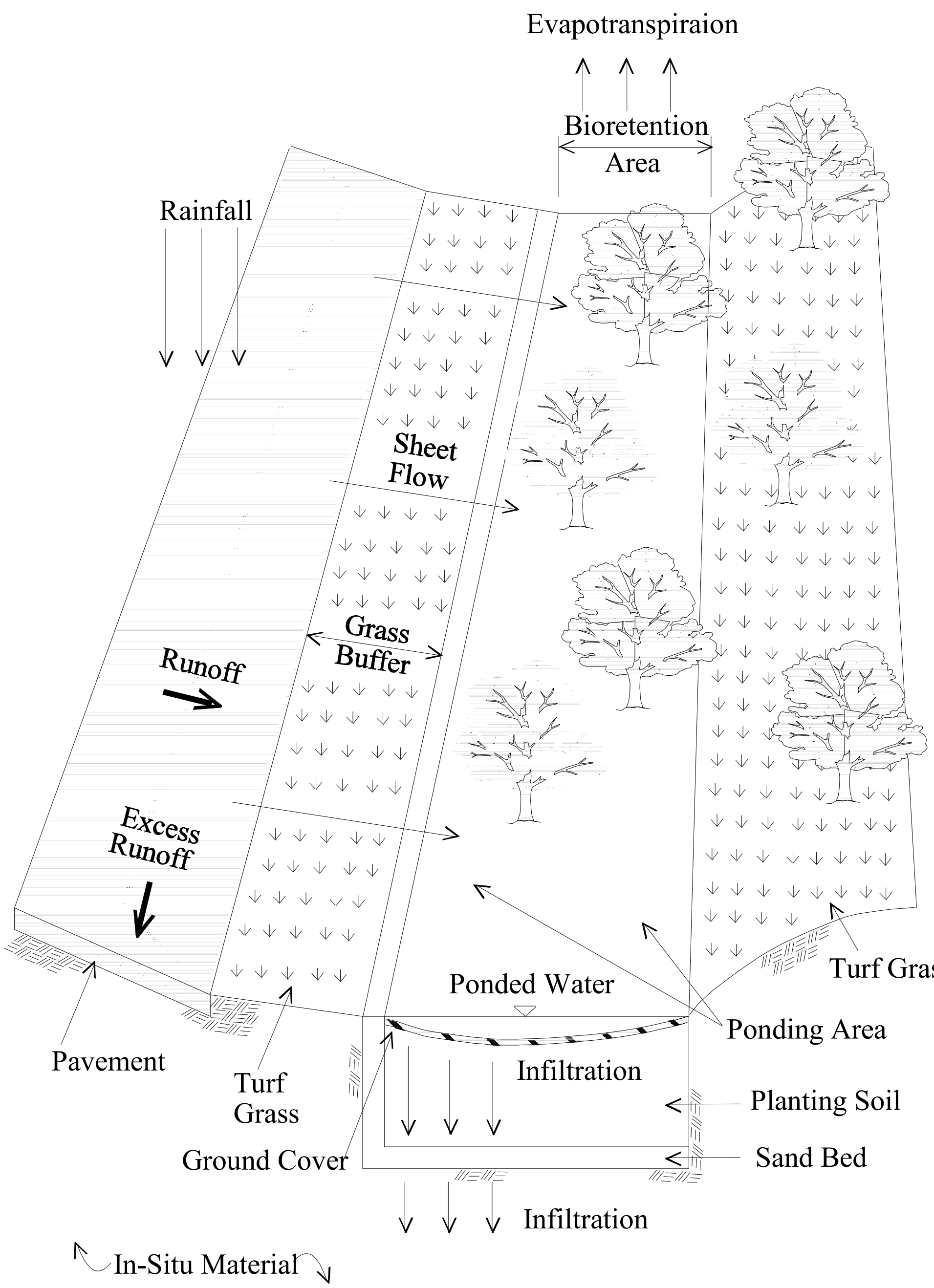


Figure 1. Schematic of a typical bioretention area BMP (adapted from Prince George's County, 1993)

ADVANTAGES

1. If designed properly, has shown ability to remove significant amounts of dissolved heavy metals, phosphorous, TSS, and fine sediments.
2. Requires relatively little engineering design in comparison to other stormwater management facilities (e.g. sand filters).
3. Provides groundwater recharge when the runoff is allowed to infiltrate into the subsurface.
4. Enhances the appearance of parking lots and provides shade and wind breaks, absorbs noise, and improves an area's landscape.
5. Maintenance on a bioretention facility is limited to the removal of leaves from the bioretention area each fall.
6. The vegetation recommended for use in bioretention facilities is generally hardier than the species typically used in parking lot landscapes. This is a particular advantage in urban areas where plants often fare poorly due to poor soils and air pollution.

LIMITATIONS

1. Low removal of nitrates.
2. Not applicable on steep, unstable slopes or landslide areas (slopes greater than 20 percent).
3. Requires relatively large areas.
4. Not appropriate at locations where the water table is within 6 feet of the ground surface and where the surrounding soil stratum is unstable.
5. Clogging may be a problem, particularly if the BMP receives runoff with high sediment loads.

DESIGN CRITERIA

1. Calculate the volume of stormwater to be mitigated by the bioretention facility using the Los Angeles County Department of Public Works *Method for Calculating Standard Urban Stormwater Mitigation Plan (SUSMP) Flow Rates and Volumes Based on 0.75-inches of Rainfall*.
2. The soil should have infiltration rates greater than 0.5 inches per hour, otherwise an underdrain system should be included (see # 11).
3. Drainage to the bioretention facility must be graded to create sheet flow, not a concentrated stream. Level spreaders (i.e. slotted curbs) can be used to facilitate sheet flow. The maximum sheet flow velocity should be 1 ft/s for the planted ground cover and 3 ft/s for mulched cover.
4. Soil shall be a uniform mix, free of stones, stumps, roots or other similar objects

larger than 1-inch in diameter. No other materials or substances shall be mixed or dumped within the bioretention area that may be harmful to plant growth, or prove a hindrance to the planting or maintenance operations. The planting soil shall be free of Bermuda grass, Quackgrass, Johnson grass, Mugwort, Nutsedge, Poison Ivy, Canadian Thistle, Tearthumb, or other noxious weeds.

5. Planting soil shall be tested and meet the following criteria:

pH range	5.2-7.0
Organic matter	1.5-4.0%
Magnesium	35 lbs. per acre, minimum
Phosphorus P_2O_5	75 lbs. per acre, minimum
Potassium K_2O	85 lbs. per acre, minimum
Soluble salts	not to exceed 500 ppm
Clay	0-25% by volume
Silt	30-55% by volume
Sand	35-60% by volume

6. It is very important to minimize compaction of both the base of the bioretention area and the required backfill. When possible, use excavation hoes to remove original soil. If excavated using a loader, the excavator should use a wide track or marsh track equipment, or light equipment with turf type tires. Use of equipment with narrow tracks or narrow tires, rubber tires with large lugs, or high pressure tires will cause excessive compaction resulting in reduced infiltration rates and storage volumes and is not acceptable. Compaction will significantly contribute to design failure.
7. Compaction can be alleviated at the base of the bioretention facility by using a primary tilling operation such as a chisel plow, ripper, or subsoiler. These tilling operations are to refracture the soil profile through the 12 inch compaction zone. Substitute methods must be approved by the engineer. Rototillers typically do not till deep enough to reduce the effects of compaction from heavy equipment. Rototill 2 to 3 inches of sand into the base of the bioretention facility before back filing the required sand layer. Pump any ponded water before preparing (rototilling) base.
8. When back filling topsoil over the sand layer, first place 3 to 4 inches of topsoil over the sand, then rototill the sand/topsoil to create a gradation zone. Backfill the remainder of the topsoil to final grade.
9. Mulch around individual plants only. Shredded hardwood mulch is the only accepted mulch. Shredded hardwood mulch must be well aged (stockpiled or stored for at least 12 months) for acceptance. The mulch should be applied to a maximum depth of 3-inches.
10. The plant root ball should be planted so $1/8^{th}$ of the ball is above final grade surface.
11. If used, place underdrains on a 3 feet wide section of filter cloth followed by a gravel bedding. Pipe is placed next, followed by the gravel bedding. The ends of underdrain pipes not terminating in an observation well shall be capped.

12. The main collector pipe for underdrain systems shall be constructed at a minimum slope of 0.5%. Observation wells and/or clean-out pipes must be provided (one minimum per every 1,000 square feet of surface area).
13. Size an emergency overflow weir with 6-inches of head, using the Weir equation:

$$Q=CLH^{3/2}$$

Where C= 2.65 (smooth crested grass weir)
Q= flow rate
H = 6-inches of head
L = length of weir

14. Bioretention areas should be at least 15 feet wide with a 25 foot width preferable, and a minimum length of 40 feet long. Generally, the length-to-width ratio should be around 2 to 1 to improve surface flow characteristics.
15. The plant soil depth should be 4 feet or more to provide beneficial root zone, both in terms of space and moisture content.
16. The depth of the ponding area should be limited to no more than 6 inches to limit the duration of standing water to no more than 4 days. If an underdrain system is used, the depth of the ponding area should be limited to no more than 1 foot. Longer ponding times can lead to anaerobic conditions that are not conductive to plant growth. Longer periods of standing water can also lead to the breeding of mosquitoes and other pests.
17. The bioretention area should be vegetated to resemble a terrestrial forest community ecosystem, which is dominated by understory trees, a shrub layer, and herbaceous ground covers. Three species each of both trees and shrubs are recommended to be planted at a rate of 1000 trees and shrubs per acre. The shrub-to-tree ratio should be 2:1 to 3:1. Trees should be spread 12 feet apart and the shrubs should be spaced 8 feet apart.

REFERENCES

1. S. Bitter and J. Keith Bowers, 1994. Bioretention as a Water Quality Best Management Practice. *Watershed Protection Techniques*, Vol. 1, No. 3. Silver Spring, MD.

2. The Center for Watershed Protection, Environmental Quality Resources and Loiederman Associates. 1997. *Maryland Stormwater Design Manual*. Prepared for: Maryland Department of the Environment. Baltimore, MD.

3. A.P. Davis, M. Shokouhian, H. Sharma, C. Minani, 1998. *Optimization of Bioretention Design for Water Quality and Hydrologic Characteristics*.

4. DEQ Storm Water Management Guidelines, Department of Environmental Quality,

State of Oregon. http://waterquality.deq.state.or.us/wq/groundwa/swmgmtguide.htm

5. *Design Manual for Use of Bioretention in Stormwater Management*, 1993. Department of Environmental Resources, Division of Environmental Management, Watershed Protection Branch, Prince George's County, MD.

6. GKY and Associates, Inc. June 1996. *Evaluation and Management of Highway Runoff Water Quality*, Publication No. FHWA-PD-96-032. Prepared for: US Department of Transportation, Federal Highway Administration. Washington, DC.

7. G.L. Hightshoe, 1988. *Native Trees, Shrubs, and Vines for Urban and Rural America*. Van Nostrand Reinhold, New York, NY.

8. *Low-Impact Development Design Manual*, November 1997. Department of Environmental Resources, Prince George's County, MD.

9. *Maryland Stormwater Design Manual Volumes I & II*, December 1999 Draft. Maryland Department of the Environment, Baltimore, MD.

10. T.R. Schueler, 1987. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban Best Management Practices*. Metropolitan Washington Council of Governments.

11. T.R. Schueler, 1992. *A Current Assessment of Urban Best Management Practices*. Metropolitan Washington Council of Governments.

B.2 CATCH BASIN INSERTS

DESCRIPTION

A catch basin insert is any device that can be inserted into an existing catch basin design to provide some level of runoff contaminant removal. Currently, there are many different catch basin insert models available, with applications ranging from trash and debris removal to carbon adsorption of aliphatic and aromatic hydrocarbons and heavy metals removal. Costs vary widely, ranging from about $40 for a simple screen bag, to over $3,000 for more complex, custom-engineered units. The most frequent application for catch basin inserts is for reduction of sediment, oil, and grease levels in stormwater runoff. These catch basin inserts should also have an overflow outlet, through which water exceeding the treatment capacity can escape without flooding the adjacent area.

ADVANTAGES

1. Provides moderate removal of larger particles and debris as pretreatment.
2. Low installation costs.
3. Units can be installed in existing traditional stormwater infrastructure.
4. Ease of installation.
5. Requires no additional land area.

LIMITATIONS

1. Vulnerable to accumulated sediments being resuspended at low flow rates.
2. Severe clogging potential if exposed soil surfaces exist upstream.
3. Maintenance and inspection of catch basin inserts may be required before and after each rainfall event, excessive cleaning and maintenance.
4. Available head to meet design criteria.
5. Dissolved pollutants are not captured by filter media.
6. Limited pollutant removal capabilities.

DESIGN CRITERIA

1. Calculate the flow rate of stormwater to be mitigated by the catch basin insert using the Los Angeles County Department of Public Works *Method for Calculating Standard Urban Stormwater Mitigation Plan (SUSMP) Flow Rates and Volumes Based on 0.75-inches of Rainfall*.
2. Insert device selected should be Best Available Technology for removing constituents of concern for the particular site.

REFERENCES

1. The Center for Watershed Protection, Environmental Quality Resources and Loiederman Associates. 1997. *Maryland Stormwater Design Manual*. Prepared for: Maryland Department of the Environment. Baltimore, MD.

2. DEQ Storm Water Management Guidelines, Department of Environmental Quality, State of Oregon. http://waterquality.deq.state.or.us/wq/groundwa/swmgmtguide.htm

3. K. H. Lichten, June 1997. *Compilation of New Development Stormwater Treatment Controls in the San Francisco Bay Area*, Bay Area Stormwater Management Agencies Association, San Francisco, CA.

The following is a list of known locations where a Catch Basin Insert device was installed. The design of the installed device in each location may vary from what is recommended in this SUSMP due to its specific circumstances. Los Angeles County does not endorse nor warranty any design used in the locations herein. Each individual case may require that the design be tailored to perform properly.

Installed Location (City/Address)	Brand/Manufacturer	Owner/Client
Los Angeles: SE corner of 6th St. & Bixel St.	Ultra-Urban Filter	City of Los Angeles
Los Angeles: NW corner of Union Ave. & 11th St.	Fossil Filter	City of Los Angeles
Beverly Hills: E/S Palm Ave. N/o Gregory Way	Ultra-Urban Filter	City of Beverly Hills
Los Angeles: NE corner of 20th St. & Maple Ave.	Not available	City of Los Angeles
Los Angeles: 1700 Wilshire Blvd. near Little St.	Drainpac	City of Los Angeles
Los Angeles: 2187 Riverside Dr.	Drainpac	Caltrans
Los Angeles: 4173 Engineering 1 Box 95153	Not available	UCLA
Los Angeles: 5360 W. Imperial Hwy	Drainpac	Caltrans
Los Angeles	Drainpac	Private

Carson	Drainpac	Private
Wilmington	Drainpac	Private
Pasadena	Drainpac	Private
San Pedro: 425 S. Palos Verdes St.	Drainpac	Port of Los Angeles
El Monte: Valley Blvd & Johnson Ave.	Ultra-Urban Filter	City of El Monte
City of Industry	Drainpac	Private
Thousand Oaks	Drainpac	Private
Calabasas	Fossil Filter	City of Calabasas
Santa Monica : SE corner of Santa Monica Blvd. & 3rd St.	Ultra-Urban Filter	City of Santa Monica
Los Angeles: 786 Mission Rd (Field Yard)	Not available	City of Los Angeles
Foothill Maintenance Station	Fossil Filter	Caltrans
Foothill Maintenance Station	Stream Guard	Caltrans
Las Flores Maintenance Station	Fossil Filter	Caltrans
Las Flores Maintenance Station	Stream Guard	Caltrans
Rosemead Maintenance Station	Fossil Filter	Caltrans
Rosemead Maintenance Station	Stream Guard	Caltrans

B.3 CISTERN

DESCRIPTION

Cisterns are containers which capture stormwater runoff as it comes down through the roof gutter system. This collected stormwater can later be used to water the garden or lawn. The collection of this stormwater reduces the amount of stormwater runoff and assists in the reduction of potential pollutants entering the stormwater conveyance system.

ADVANTAGES

1. Low installation cost.
2. Requires little space for installation.
3. Reduces amount of stormwater runoff.
4. Conserves water usage.

LIMITATIONS

1. Limited amount of stormwater runoff can be captured.
2. Restricted to structure runoff.
3. Aesthetically unpleasing.

DESIGN CRITERIA

1. Calculate the volume of stormwater to be mitigated by the cistern using the Los Angeles County Department of Public Works *Method for Calculating Standard Urban Stormwater Mitigation Plan (SUSMP) Flow Rates and Volumes Based on 0.75-inches of Rainfall*.

REFERENCES

1. *Low-Impact Development Design Manual*, November 1997. Department of Environmental Resources, Prince George's County, MD.

2. Rainwater Collection and Gray Water as alternative Water Supply Sources. http://www.mindspring.com/~roadrunner1/Family_Focus/Rainwater_Collection.html.

3. T. Richman, J. Worth, P. Dawe, J. Aldrich, and B. Ferguson, 1997. *Start at the Source: Residential Site Planning and Design Guidance Manual for Stormwater Quality Protection*, Bay Area Stormwater Management Agencies Association, San Francisco, CA.

B.4 CONSTRUCTED WETLANDS

DESCRIPTION

Wetlands provide physical, chemical, and biological water quality treatment of stormwater runoff. Physical treatment occurs as a result of decreasing flow velocities in the wetland, and is present in the form of evaporation, sedimentation, adsorption, and/or filtration. Chemical processes include chelation, precipitation, and chemical adsorption. Biological processes include decomposition, plant uptake and removal of nutrients, plus biological transformation and degradation. Hydrology is one of the most influential factors in pollutant removal due to its effects on sedimentation, aeration, biological transformation, and adsorption onto bottom sediments (Dormann, et al., 1988). The large surface area of the bottom of the wetland encourages higher levels of adsorption, absorption, filtration, microbial transformation, and biological utilization than might normally occur in more channelized water courses.

A natural wetland is defined by examination of the soils, hydrology, and vegetation which are dominant in the area. Wetlands are characterized by the substrate being predominantly undrained hydric soil. A wetland may also be characterized by a substrate which is non-soil and is saturated with water or covered by shallow water at some time during the growing season of each year. Wetlands also usually support hydrophytes, or plants which are adapted to aquatic and semiaquatic environments. Natural and artificial wetlands are used to treat stormwater runoff. Figure 1 illustrates an artificial wetland used for treating stormwater runoff.

The success of a wetland will be much more likely if some general guidelines are followed. The wetland should be designed such that a minimum amount of maintenance is required. This will be affected by the plants, animals, microbes, and hydrology. The natural surroundings, including such things as the potential energy of a stream or a flooding river, should be utilized as much as possible. It is necessary to recognize that a fully functional wetland cannot be established spontaneously. Time is required for vegetation to establish and for nutrient retention and wildlife enhancement to function efficiently. Also, the wetland should approximate a natural situation as much as possible, and unnatural attributes, such as a rectangular shape or a rigid channel, should be avoided (Mitsch and Gosselink, 1993).

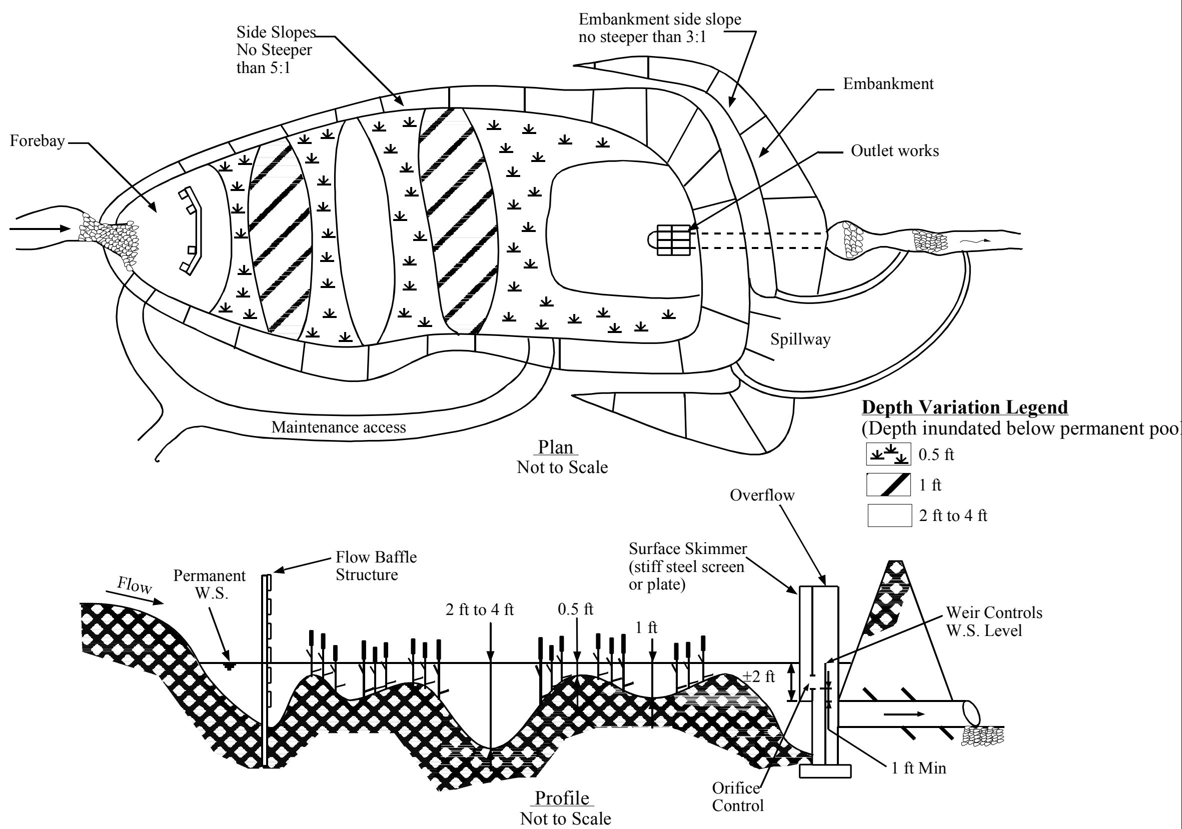


Figure 1. Plan and profile of a wetland pond (adapted from Urbanos, 1992).

1. *Natural Wetland Systems*. If a natural wetland site is potentially available for use to treat stormwater runoff, an assessment should be done to determine whether treatment of stormwater runoff would be appropriate. Important characteristics to look for in a potential natural wetland site include the wetland vegetation, the type of wetland, the existing wetland hydrology, and the geomorphology at the potential site.

   Wetland vegetation can be categorized as either emergent, floating, or submerged. Emergent vegetation is rooted in the sediments, but grows through the water and above the water surface. Floating vegetation is not rooted in the sediments, and has aquatic roots with plant parts partly submerged or fully exposed on the water or surface. Submerged vegetation includes aquatic plants such as algae or plants rooted in the sediments, with all plant parts growing within the water column. Pollutant removal rates generally improve with an increase in the diversity of the vegetation.

The depth of inundation will contribute to the pollutant removal efficiency. Generally, shallow water depths allow for higher pollutant removal efficiencies due to an increased amount of adsorption onto bottom sediments (Dormann, et al.,1988). The water budget of the wetland should be calculated to determine the mean residence time of the wetland, assuming there is no change in storage. Water budget calculations should include precipitation, overland flow from other sources, groundwater, evapotranspiration, and any stormwater runoff into and out of the wetland. Flow patterns in the wetland will affect the removal efficiency also. Meandering channels, slow-moving water and a large surface area will increase pollutant removal through increased sedimentation. Shallow, sheet flow also increases the pollutant removal capabilities, through assimilative processes. A deep pool sometimes improves the denitrification potential. A mixed flow pattern will increase overall pollutant removal efficiency (Dormann, et al., 1988).

2. *Artificial wetlands.* Site considerations should include the water table depth, soil/substrate, and space requirements. Because the wetland must have a source of flow, it is desirable that the water table is at or near the surface. This is not always possible. If runoff is the only source of inflow for the wetland, the water level often fluctuates and establishment of vegetation may be difficult. The soil or substrate of an artificial wetland should be loose loam to clay. A perennial base flow must be present to sustain the artificial wetland. The presence of organic material is often helpful in increasing pollutant removal and retention.

   Using a site where wetlands previously existed or where nearby wetlands still exist is recommended if possible. A hydrologic study should be done to determine if flooding occurs and saturated soils are present. A site where natural inundation is frequent is a good potential site (Mitsch and Gosselink, 1993). Loamy soils are required to permit plants to take root (Urbonas, 1992)

ADVANTAGES

1. Artificial wetlands offer natural aesthetic qualities, wildlife habitat, erosion control, and pollutant removal.
2. Artificial wetlands can offer good treatment following treatment by other BMPs, such as wet ponds, that rely upon settling of larger sediment particles (Urbonas, 1992). They are useful for large basins when used in conjunction with other BMPs.
3. Wetlands which are permanently flooded are less sensitive to polluted water inflows because the ecosystem does not depend upon the polluted water inflow.
4. Can provide uptake of soluble pollutants such as phosphorous, through plant uptake.
5. Can be used as a regional facility.

LIMITATIONS

1. Although the use of natural wetlands may be more cost effective than the use of an artificial wetland; environmental, permitting and legal issues may make it difficult to use natural wetlands for this purpose.
2. Wetlands require a continuous base flow.
3. If not properly maintained, wetlands can accumulate salts and scum which can be flushed out by large storm flows.
4. Regular maintenance, including plant harvesting, is required to provide nutrient removal.
5. Frequent sediment removal is required to maintain the proper functioning of the wetland.
6. A greater amount of space is required for a wetland system than is required for an extended/dry detention basin treating the same amount of area.
7. Although artificial wetlands are designed to act as nutrient sinks, on occasion, the wetland may periodically become a nutrient source.
8. Wetlands which are not permanently flooded are more likely to be affected by drastic changes in inflow of polluted water.
9. Cannot be used on steep unstable slopes or densely populated areas.
10. May be regulated under Chapter 15, Title 23, California Code of Regulations regarding waste disposal to land.
11. Threat of mosquitoes.
12. Hydraulic capacity may be reduced with plant overgrowth.

DESIGN CRITERIA

The wetland may be designed as either a stand-alone BMP, or as part of a larger non-point source treatment facility in conjunction with other devices, such as a wet pond, sediment forebay, or infiltration basin. Basic design elements and considerations are listed below.

1. *Volume.* The wetland pond should provide a minimum permanent storage equal to three-fourths of the water quality control volume. The full water quality capture volume should be provided above the permanent pool. Calculate the water quality volume to be mitigated by the wetland using the Los Angeles County Department of Public Works *Method for Calculating Standard Urban Stormwater Mitigation Plan (SUSMP) Flow Rates and Volumes Based on 0.75-inches of Rainfall*.
2. *Depth.* A constant shallow depth should be maintained in the wetland, at approximately 1 ft or less (Schueler, 1987; Boutiette and Duerring, 1994), with 0.5 ft being more desirable (Schueler, 1987). If the wetland is designed as a very shallow detention pond, the pond should provide the full water quality capture volume above the permanent pool level. The permanent wetland depth should be 6 to 12 inches deep. The depth of the water quality capture volume above the permanent pool should not exceed 2 ft (Urbonas, 1992). Regrading may be necessary to allow for this shallow depth over a large area.

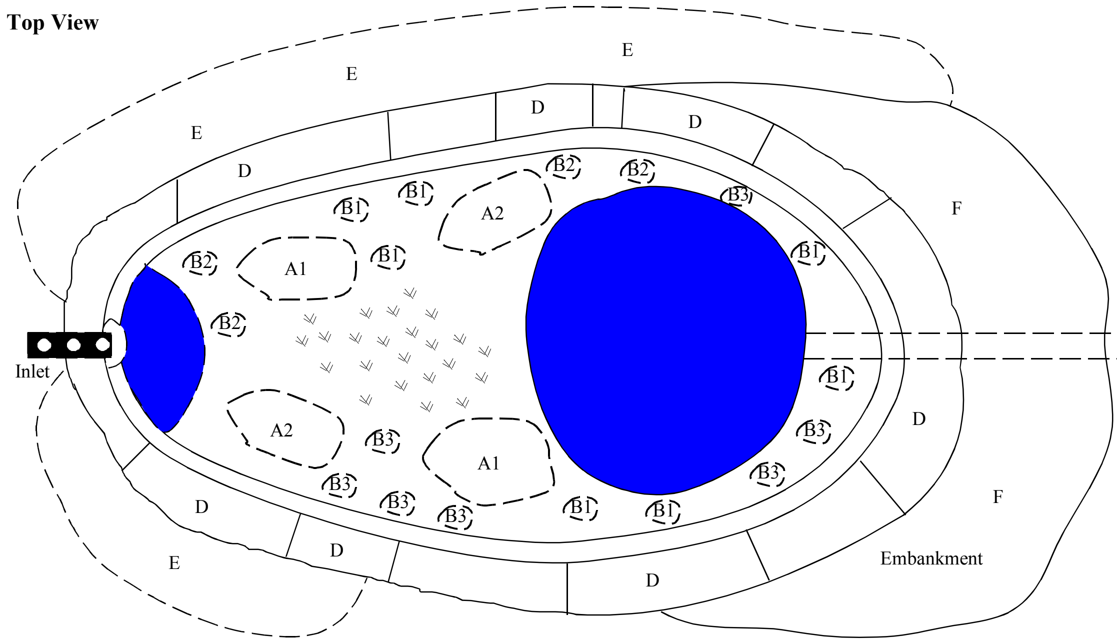
It may also be beneficial to create a wetland with a varying depth. A varying depth within the wetland will enable more diverse vegetation to flourish. Deep water offers a habitat for fish, creates a low velocity area where flow can be redistributed, and can enhance nitrification as a prelude to later denitrification if nitrogen removal is desired. Open-water areas may vary in depth between 2 and 4 ft (Urbonas, 1992).

3. *Surface Area.* Increasing the surface area of the pond increases the nutrient removal capability (Boutiette and Duerring, 1994). A general guideline for surface area is using a marsh area of two to three percent of the contributing drainage area. The minimum surface area of the pond can also be calculated by determining the nutrient loading to the wetland. The nutrient loading to a wetland used for stormwater treatment should not be more than 45 lbs/ac of phosphorus or 225 lbs/ac of nitrogen per year. The pond could be sized to meet this minimum size requirement if the annual nutrient load at the site is known (Schueler, 1987).
4. *Longitudinal Slope.* Both wetland ponds and channels require a near-zero longitudinal slope (Urbonas, 1992).
5. *Base flow.* Enough inflow must be present in the wetland to maintain wetland soil and vegetation conditions. A base flow should be used. Dependence on groundwater for a moisture supply is not recommended.
6. *Seeding.* It is important that any seed which is used to establish vegetation germinate and take root before the site is inundated, or the seeds will be washed away.
7. *Length to Width Ratio.* The pond should gradually expand from the inlet and gradually contract toward the outlet. The length to width ratio of the wetland should be 2:1 to 4:1, with a length to width ratio of 3:1 recommended (Urbonas, 1992)
8. *Emptying Time.* The water quality volume above the permanent pool should empty in 24 hours (Urbonas, 1992). This emptying time is not for the wetland itself, but for the additional storage above the wetland.
9. *Inlet and Outlet Protection.* Inlet and outlet protection should be provided to reduce erosion of the basin. Velocity should be reduced at the entrance to reduce resuspension of sediment by using a forebay. The forebay should be approximately 5 to 10 percent of the water quality capture volume. The outlet should be placed in an offbay at least 3 ft deep. It may be necessary to protect the outlet with a skimmer shield that starts approximately one-half of the depth below the permanent water surface and extends above the maximum capture volume depth. A skimmer can be constructed from a stiff steel screen material that has smaller openings than the outlet orifice or perforations.
10. *Infiltration Avoidance.* Loss of water through infiltration should be avoided. This can be done by compacting the soil, incorporating clay into the soil, or lining the pond with artificial lining.
11. *Side Slopes.* Side slopes should be gradual to reduce erosion and enable easy maintenance. Side slopes should not be steeper than 4:1, and 5:1 is preferable (Urbonas, 1992).
12. *Open Water.* At least 25 percent of the basin should be an open water area at least 2 ft deep if the device is exclusively designed as a shallow marsh. The open water

area will make the marsh area more aesthetically pleasing, and the combined water/wetland area will create a good habitat for waterfowl (Schueler, 1987). The combination of forebay, outlet and free water surface should be 30 to 50 percent, and this area should be between 2 and 4 ft deep. The wetland zone should be 50 to 70 percent of the area, and should be 6 to 12 inches deep (Urbonas, 1992).

13. *Freeboard.* The wetland pond should be designed with at least 1 ft of freeboard (Camp, Dresser and McKee, 1993).
14. *Use with Wet Pond.* Shallow marshes can be established at the perimeter of a wet pond by grading to form a 10 to 20 ft wide shallow bench. Aquatic emergent vegetation can be established in this area. A shallow marsh area can also be used near the inflow channel for sediment deposition (Schueler, 1987).
15. *Shape.* The shape is an important aspect of the wetland. It is recommended that a littoral shelf with gently sloping sides of 6:1 or milder to a point 24 to 28 inches below the water surface (Mitsch and Gosselink, 1993). Bottom slopes of less than one percent slope are also recommended.
16. *Soils*. Clay soils underlying the wetland will help prevent percolation of water to groundwater. However, clay soils will also prevent root penetration, inhibiting growth. Loam and sandy soils may then be preferable. A good design may be use of local soils at the upper layer with clay beneath to prevent infiltration (Mitsch and Gosselink, 1993).
17. *Vegetation.* Vegetation must be established in the wetland to aid in slowing down velocities, and nutrient uptake in the wetland. A dependable way of establishing vegetation in the wetland is to transplant live plants or dormant rhizomes from a nursery. Emergent plants may eventually migrate into the wetland from upstream, but this is not a reliable source of vegetation. Transplanting vegetation from existing wetland areas is not encouraged, as it may damage the existing wetland area. Seeding is more cost effective, but is also not reliable.

    Plants which should be planted on the wetland bottom include cattails, sedges, reeds, and wetland grasses. Berms and side-slopes should be planted with native or irrigated turf-forming grasses. To allow the vegetation to establish, it may be necessary to initially lower the permanent pool, perhaps 3 to 4 inches.



LEGEND
- A1: Primary Wetland Species
- A2: Primary Wetland Species
- B1: Secondary Wetland Species
- B2: Secondary Wetland Species
- B3: Secondary Wetland Species
- C: Deep Open Water Areas (No Vegetation)
- D: Shoreline Fringe of Switchgrass, 50% of Safety Bench Perimeter
- E: Wildlife Trees and Shrubs in Bugger
- F: Maintain Grass Cover on Embankment (No Trees)

Figure 2. Examples of shallow marsh planting strategies (adapted from Schueler, 1987).

Table 1. Wetland plant species (Schueler, 1987).

Plant Name	***Zone***	***Form***	***Tolerance for Periodic Inundation***	***Comments***
Arrow Arum/ Duck Corn (Peltandra virginica)	2	Emergent	to 1 ft depth	Slow colonizer
Arrowhead/ Duck Potato (Saggitaria latifolia	2	Emergent	to 1 ft to 1.5 ft depth	Aggressive colonizer
Buttonbush (Cephalanthus occidentalis)	2, 3	Emergent	to 2 ft depth	Full sun required
Broomsedge (Andropogon virginianus)	2, 3	Perimeter	to 3 in depth	tolerates fluctuating water levels
Cattail (Typha spp.)	2, 3	Emergent	to 1 ft depth	Volunteer, aggressive colonizer

Coontail (Ceratophyllum demersum)	1	Submergent	1 ft to 6 ft deep	
Common Three-Square (Scirpus americanus)	2	Emergent	to 6 in deep	Fast colonizer, tolerates fluctuating water levels
Lizard's Tale (Saururus cernuus)	2	Emergent	to 1 ft	Rapid growing, shade tolerant
Marsh Hibiscus (Hibiscus moscheutos)	2, 3	Emergent	to 3 in	
Pickerelweed (Pontederia cordata)	2, 3	Emergent	to 0.5 ft to 1.0 ft	
Pond Weed (Potamegaton)	2, 3	Submergent	1.5 ft to 3.0 ft deep	
Rice Cutgrass (Leersia oryzoides)	2, 3	Emergent	to 3 in deep	Shade tolerant
Sedges (Cyperus spp.)	2, 3	Emergent	to 3 in deep	
Soft-stem Bulrush (Scirpus validus)	2, 3	Emergent up to 3 m	to 1.0 ft	Aggressive colonizer
Smartweed (Polygonum spp.)	2	Emergent	to 1 ft deep	Fast colonizer
Spatterdock (Nuphar luteum)	2	Emergent	to 1.5 ft	Fast colonizer, deals with fluctuating water levels
Switchgrass (Panicum virgatum)	2, 3, 4, 5, 6	Perimeter emergent	to 3 in deep	Tolerates wet/dry conditions
Sweet Flag (Acorus calamus)	2, 3	Perimeter emergent 2 to 4.5 ft	to 3 in deep	Slow colonizer, tolerates drying
Water Iris (Iris pseudoacorus)	2, 3	Perimeter	to 3 in deep	Attractive, ornamental
Water Cress (Nasturtium officianale)	Flowing water		to 6 in deep	

Zones listed in table:

1. Deep water pool (1 ft to 6 ft deep).
2. Shallow water bench (6 in to 12 in deep).
3. Shoreline fringe (regularly inundated).
4. Riparian fringe (periodically inundated).
5. Floodplain terrace (infrequently inundated).
6. Upland slopes (seldom or never inundated).

The vegetation planted in and around the wetland should correspond to the hydrology of the wetland. This information is unique to specific geographic locations. Topsoiling of the surface prior to planting may not always be necessary. The wetland plants themselves often produce a substantial amount of organic matter below the ground. Topsoiling may be needed if the soils are composed of mainly clay, rock, or pyritic soils. Although KY-31 Tall Fescue has often been used to reduce erosion, it may displace native grass and meadow species, and possibly overtake some of the wetland. Use of this grass type is questionable because of its aggressive nature (The Center for Watershed Protection, 1994).

REFERENCES

1. L. N. Boutiette and C. L. Duerring, 1994. *Massachusetts Nonpoint Source Management Manual, The Megamanual: A Guidance Document for Municipal Officials*, Massachusetts Department of Environmental Protection, Office of Watershed Management, Nonpoint Source Program, Boston, MA.

2. Camp, Dresser and McKee, Inc., Larry Walker Associates, 1993. *California Best Management Practices - Municipal*, California State Water Resources Council Board, Alameda, CA.

3. The Center for Watershed Protection, 1994. *Watershed Protection Techniques*, Vol. 1 No. 2, The Center for Watershed Protection, Silver Spring, MD.

4. M. E. Dormann, J. Hartigan, and B. Maestri, 1988. *Retention, Detention, and Overland Flow for Pollutant Removal from Highway Stormwater Runoff: Interim Guidelines for Management Measures*, FHWA/RD-87/056, Federal Highway Administration, Versar, Inc., Springfield, VA.

5. GKY and Associates, Inc. June 1996. *Evaluation and Management of Highway Runoff Water Quality*, Publication No. FHWA-PD-96-032. Prepared for: US Department of Transportation, Federal Highway Administration. Washington, DC.

6. W. J. Mitsch and J. G. Gosselink, 1993. *Wetlands*, Van Nostrand Reinhold, New York, NY.

7. T. R. Schueler, 1987. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs*, Department of Environmental Programs, Metropolitan Washington Council of Governments, Washington, DC.

8. B. R. Urbonas, J. T. Doerfer, J. Sorenson, J. T. Wulliman, and T. Fairley, 1992. *Urban Storm Drainage Criteria Manual, Volume 3 - Best Management Practices, Stormwater Quality, Urban Drainage and Flood Control District*, Denver, CO.

9. Ventura Countywide Stormwater Quality Management Program, *Draft BMP CW: Constructed Wetlands*, June 1999. Ventura, CA.

The following is a known location where a Constructed Wetland was installed. The design of the installed wetland in the location may vary from what is recommended in this SUSMP due to its specific circumstances. Los Angeles County does not endorse nor warranty any design used in the location herein. Each individual case may require that the design be tailored to perform properly.

Installed Location (City/Address)	Brand/Manufacturer	Owner/Client
Malibu	N/A	Las Virgenes MWD

B.5 DRY WELLS

DESCRIPTION

Commonly known as sumps, french drains, drainfields, and shallow injection wells, dry wells and other such devices simply use gravity to emplace stormwater into the subsurface. A dry well is constructed by digging a hole in the ground and filling it with an open graded aggregate. Stormwater runoff is then diverted to the dry well for infiltration into the ground, allowing it to be stored in the voids. While it may seem harmless and cost-effective at first glance to use these dry wells to infiltrate into the ground, in reality, the impact to groundwater quality from these devices varies and is highly dependent upon many factors.

ADVANTAGES

1. Requires minimal space to install.
2. Low installation costs.
3. Reduces amount of runoff.
4. Provides groundwater recharge.
5. Can serve small impervious areas like rooftops.
6. Helps to disconnect impervious surfaces.

LIMITATIONS

1. Offers little pretreatment which may cause clogging.
2. Dry wells should not be installed where hazardous or toxic materials are used, handled, stored or where a spill of such materials would drain into the dry well.
3. Risk of groundwater contamination in very coarse soils, may require groundwater monitoring.
4. Not suitable on fill sites or steep slopes.
5. Must have a minimum of 3 to 4 feet between the bottom of the dry well and the seasonal high water table.
6. Dry wells service a limited drainage area, typically only rooftop runoff.
7. Dry wells must be located at least 10 feet away, on the down slope side of the structure, from building foundations to prevent seepage.
8. Stormwater runoff carrying bacteria, sediment, fertilizer, pesticides and other chemicals may flow directly into the groundwater.
9. Loss of infiltrative capacity and high maintenance cost in fine soils.
10. Low removal of dissolved pollutants in very coarse soils.
11. Soils must be permeable.
12. Not recommended for use with commercial rooftops unless adequacy of pretreatment is assured.

DESIGN CRITERIA

1. Calculate the volume of stormwater to be mitigated by the dry well using the Los Angeles County Department of Public Works *Method for Calculating Standard Urban Stormwater Mitigation Plan (SUSMP) Flow Rates and Volumes Based on 0.75-inches of Rainfall*.
2. For drainage systems draining paved areas, a minimum of one standard dry well shall be installed for each 6,000 cubic feet of drainage volume, 15,000 cubic feet of drainage volume for landscaped areas.
3. A standard dry well system shall have a minimum effective settling capacity of 1,000 gallons per chamber. (Effective settling capacity equals the distance from the bottom of the settling chamber to the height of the overflow outlet.)
4. Systems are to use a shielding device to enhance separation of petrochemicals from water by gravity differentials. Such devices are to be vented to prevent siphoning or skimming of floating petrochemicals.
5. Systems are to use a hydrophobic petrochemical absorbent with a minimum capacity of at least 128 ounces.
6. A device to screen floating debris such as paper, leaves and other trash must be used to retain such material within the settling chamber.
7. The system must be accessible from the surface for maintenance and inspection. Standard minimum opening is a 24 inch diameter nominal size cast iron grating or manhole cover bolted in at least two locations.
8. A minimum penetration of 10 continuous feet into permeable porous soils is recommended for standard installations. In unstable sandy, gravely soils where “belling out” is a problem, an equivalent of 200 square feet of sidewall area is acceptable (bottom area is not to be included). If such penetration is not achieved or if the required design performance rate is greater than 0.25 cubic feet per second, a constant head percolation test on the completed system will be required to determine performance.
9. Multiple dry wells should be spaced a minimum of 100 feet apart center to center.
10. Inlet connecting pipes to dry well systems should be a maximum of 6 inches in diameter.
11. Dry well surface grates should be raised a minimum of 3 inches above bottom of landscaped retention basins.
12. During construction, dry well inlets (including any remote inlets) should be sealed with two layers of UV protected geotextile fabric to prevent sediments from entering the dry wells until paving and landscaping are complete.

REFERENCES

1. Arizona Department of Environmental Quality, 1995. *Guidance for Design,*

Installation, Operation, and Maintenance of Dry Wells, Arizona Department of Environmental Quality, AZ.

2. DEQ Storm Water Management Guidelines, Department of Environmental Quality, State of Oregon. http://waterquality.deq.state.or.us/wq/groundwa/swmgmtguide.htm

3. *Low-Impact Development Design Manual*, November 1997. Department of Environmental Resources, Prince George's County, MD.

4. T. Richman, J. Worth, P. Dawe, J. Aldrich, and B. Ferguson, 1997. *Start at the Source: Residential Site Planning and Design Guidance Manual for Stormwater Quality Protection*, Bay Area Stormwater Management Agencies Association, San Francisco, CA.

The following is a known location where a Drywell was installed. The design of the installed drywell in the location may vary from what is recommended in this SUSMP due to its specific circumstances. Los Angeles County does not endorse nor warranty any design used in the location herein. Each individual case may require that the design be tailored to perform properly.

Installed Location (City/Address)	**Brand/Manufacturer**	**Owner/Client**
Calabasas	N/A	City of Calabasas

B.6 EXTENDED/DRY DETENTION BASINS OR UNDERGROUND DETENTION TANKS

DESCRIPTION

Extended/dry detention basins are depressed basins that temporarily store a portion of stormwater runoff following a storm event. Underground detention tanks function similar to detention basins. However, since underground detention tanks are located below ground, the surface above these systems can be utilized for other more useful needs (parking lots, sidewalks, landscaping adjacent to buildings, etc). Water is controlled by means of a hydraulic control structure (orifice and/or weirs) to restrict outlet discharge. The extended/dry detention basins and underground detention tanks normally do not have a permanent water pool between storm events. The objectives of both systems are to remove particulate pollutants and to reduce maximum runoff values associated with development to their pre-development levels. Detention basin facilities may be berm-encased areas or excavated basins. Detention tank facilities may be corrugated metal pipe, concrete pipe, or vaults.

ADVANTAGES

1. Modest removal efficiencies for the larger particulate fraction of pollutants.
2. Removal of sediment and buoyant materials. Nutrients, heavy metals, toxic materials, and oxygen-demanding particles are also removed with sediment substances associated with the particles.
3. Can be designed for combined flood control and stormwater quality control.
4. Requires less capital cost and land area when compared to wet pond BMP.
5. Downstream channel protection when properly designed and maintained.

LIMITATIONS

1. Require sufficient area and hydraulic head to function properly.
2. Generally not effective in removing dissolved and finer particulate size pollutants from stormwater.
3. Some constraints other than the existing topography include, but are not limited to, the location of existing and proposed utilities, depth to bedrock, location and number of existing trees, and wetlands.
4. Extended/dry detention basins have moderate to high maintenance requirements.
5. Sediments can be resuspended if allowed to accumulate over time and escape through the hydraulic control to downstream channels and streams.
6. Some environmental concerns with using extended/dry detention basins, include potential impact on wetlands, wildlife habitat, aquatic biota, and downstream water quality.
7. May create mosquito breeding conditions and other nuisances.

DESIGN CRITERIA

EXTENDED/DRY DETENTION BASINS:

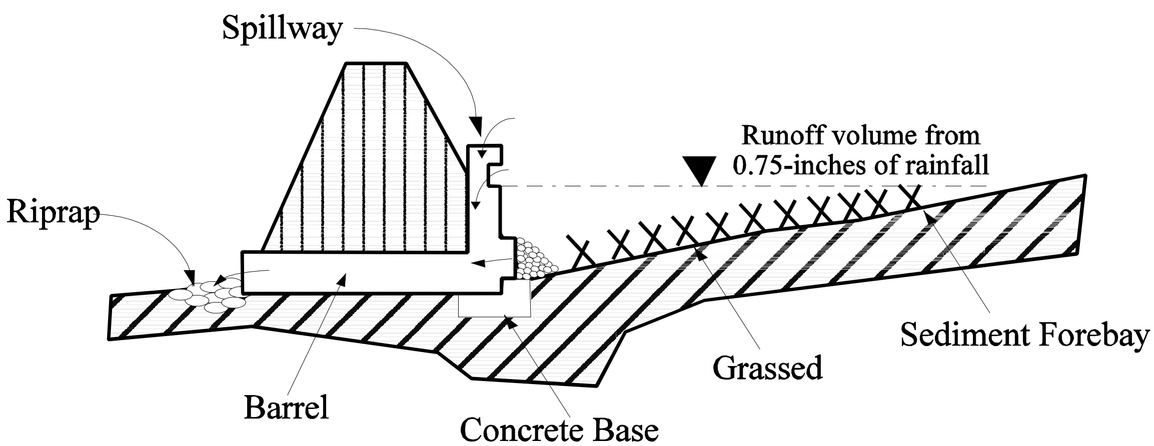


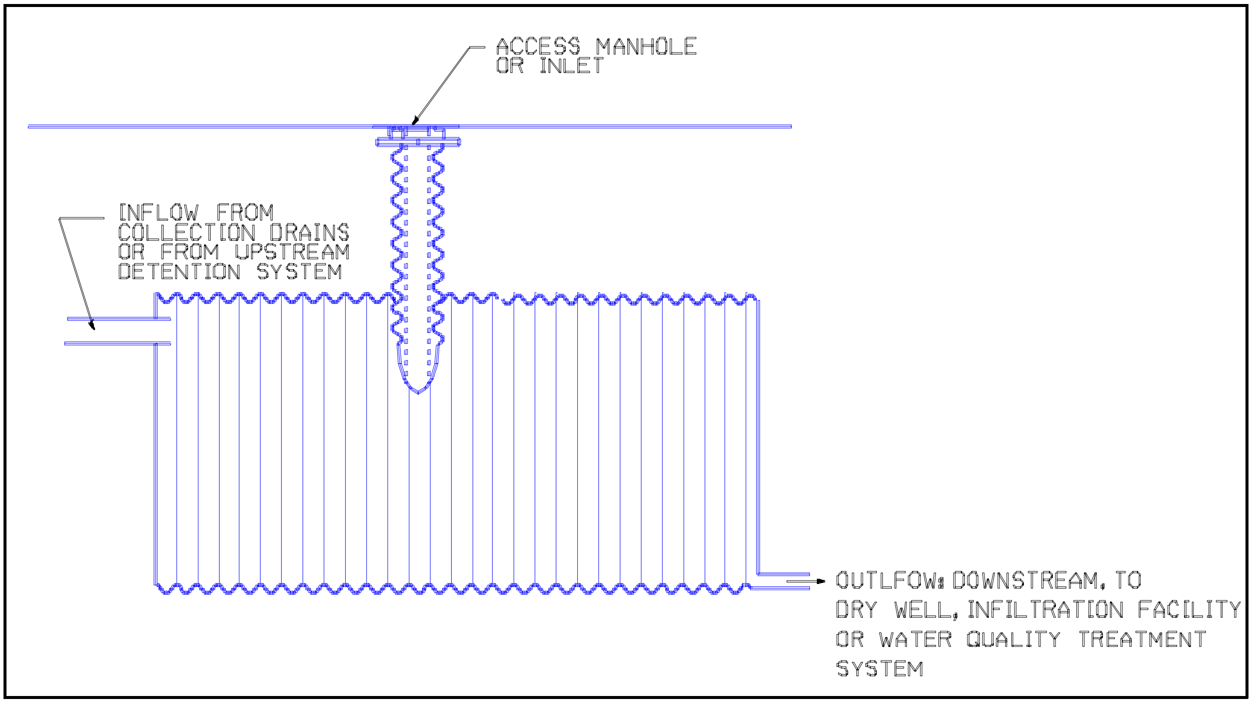
Figure 1. Conceptual elements of typical extended/dry detention structures.

Criteria	*Design Considerations*
Storage volume	Calculate the volume of stormwater to be mitigated by the extended/dry detention basin using the Los Angeles County Department of Public Works *Method for Calculating Standard Urban Stormwater Mitigation Plan (SUSMP) Flow Rates and Volumes Based on 0.75-inches of Rainfall*. Provide a storage volume for 120 percent of the runoff volume generated from 0.75-inches of rainfall above the lowest outlet in the basin. The additional 20 percent of storage volume provides for sediment accumulation and the resultant loss in storage volume.
Emptying time	A 24- to 48-hour emptying time should be used for the runoff volume generated from 0.75-inches of rainfall, with no more than 50 percent of the 0.75-inches of rainfall being released in 12 hours.
Basin geometry	Shape the pond with a gradual expansion from the inlet and a gradual contraction toward the outlet, thereby limiting short circuiting. The basin length to width ratio should be not less than 4.
Two-stage design	A two-stage design with a lower frequency pool that fills often with frequently occurring runoff minimizes standing water and sediment deposition in the remainder of the basin can enhance water quality benefits. The bottom stage should store 10 to 25 percent of the runoff volume generated from 0.75-inches of rainfall.
Low-flow channel	Conveys low base flows from the forebay to the outlet. Erosion protection should be provided for the low-flow channel.

Basin side slopes	Slopes should be stable and gentle enough to limit rill erosion and facilitate maintenance access and needs. Side slopes should be no steeper than 4:1 (H:V), preferably flatter.
Inlet	Dissipate flow energy at basin's inflow point(s) to limit erosion and promote particle sedimentation.
Forebay design	Provide the opportunity for larger particles to settle out in an area that has, as a useful refinement, a solid surface bottom to facilitate mechanical sediment removal. The forebay volume should be 5 to 10 percent of the runoff volume generated from 0.75-inches of rainfall.
Outlet design	Use a water quality outlet that is capable of slowly releasing the runoff volume generated from 0.75-inches of rainfall over a 24- to 48-hour period. A perforated riser can be used in conjunction with orifices and a weir box opening above it to control larger storm outflows. A cutoff collar should be considered for the outlet pipe to control seepage.
Perforation protection	Provide a crushed rock blanket of sufficient size to prevent clogging of the primary water quality outlet while not interfering significantly with its hydraulic capacity.
Dam embankment	The embankment should be designed not to fail during a 100-yr and larger storm. Embankment slopes should be no steeper than 3:1 (H:V), preferably 4:1, and flatter, and planted with turf-forming grasses. Poorly compacted native soils should be excavated and replaced. Embankment soils should be compacted to at least 95 percent of their maximum density. Spillway structures and overflows should be designed in accordance with local drainage criteria.
Vegetation	Bottom vegetation provides erosion control and sediment entrapment. Basin bottom, berms, and side-sloping areas may be planted with native grasses or with irrigated turf, depending on the local setting.
Maintenance access	Access to the forebay and outlet area shall be provided to maintenance vehicles. Maximum grades should be eight percent, and a solid driving surface of gravel, rock, concrete, or gravel-stabilized turf should be provided.

UNDERGROUND DETENTION TANKS:

Figure 2. Conceptual elements of typical underground detention structures.



CRITERIA	***DESIGN CONSIDERATIONS***
Storage volume	Calculate the volume of stormwater to be mitigated by the underground detention tank using the Los Angeles County Department of Public Works Method for Calculating Standard Urban Stormwater Mitigation Plan (SUSMP) Flow Rates and Volumes Based on 0. 75-inches of Rainfall Provide a storage volume for 120 percent of the runoff volume generated from 0.75-inches of rainfall above the lowest outlet in the tank. The additional 20 percent of storage volume provides for sediment accumulation and the resultant loss in storage volume.
Emptying time	A 24- to 48-hour emptying time should be used for the runoff volume generated from 0.75-inches of rainfall, with no more than 50 percent of the 0.75-inches of rainfall being released in 12 hours.
Tank geometry	Tank should be constructed to fit within the site layout.
Low-flow outlet	Conveys low base flows from the tank to the outlet.
Outlet design	Use a water quality outlet that is capable of slowly releasing the runoff volume generated from 0.75-inches of rainfall over a 24- to 48-hour period.
Over flow design	Runoff volume generated from a storm greater than a 0.75-inches rainfall event should be diverted via a flow splitter placed at the tank entrance or an overflow weir/orifice system designed in conjunction with the outlet of the tank.
Maintenance access	Access to the tanks shall be provided for maintenance personal.

REFERENCES

1. Camp, Dresser and McKee, Inc., Larry Walker Associates, 1993. *California Best Management Practices - Municipal*, California State Water Resources Council Board, Alameda, CA.

2. GKY and Associates, Inc. June 1996. *Evaluation and Management of Highway Runoff Water Quality*, Publication No. FHWA-PD-96-032. Prepared for: US Department of Transportation, Federal Highway Administration. Washington, DC.

3. K. H. Lichten, June 1997. *Compilation of New Development Stormwater Treatment Controls in the San Francisco Bay Area*, Bay Area Stormwater Management Agencies Association, San Francisco, CA.

4. *Low-Impact Development Design Manual*, November 1997. Department of Environmental Resources, Prince George's County, MD.

5. T. R. Schueler, 1987. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs*, Department of Environmental Programs, Metropolitan Washington Council of Governments, Washington, DC.

6. Ventura Countywide Stormwater Quality Management Program, *Draft BMP DD: Extended Dry Detention Basins*, June 1999. Ventura, CA.

7. G. K. Young and F. Graziano, 1989. *Outlet Hydraulics of Extended Detention Facilities*, Northern Virginia Planning District Commission, Annandale, VA.

The following is a list of known locations where an Extended Dry Detention Basin was installed. The design of the installed basin in each location may vary from what is recommended in this SUSMP due to its specific circumstances. Los Angeles County does not endorse nor warranty any design used in the locations herein. Each individual case may require that the design be tailored to perform properly.

Installed Location (City/Address)	**Brand/Manufacturer**	**Owner/Client**
I-5/I-605 Intersection	N/A	Caltrans
I-605/SR 91 Intersection	N/A	Caltrans

B.6 EXTENDED/DRY DETENTION BASINS

DESCRIPTION

Extended/dry detention basins are depressed basins that temporarily store a portion of stormwater runoff following a storm event. Water is controlled by means of a hydraulic control structure to restrict outlet discharge. The extended/dry detention basins normally do not have a permanent water pool between storm events. The objectives of extended/dry detention basins are to remove particulate pollutants and to reduce maximum runoff values associated with development to their pre-development levels. Detention facilities may be berm-encased areas, excavated basins, or tanks.

ADVANTAGES

1. Modest removal efficiencies for the larger particulate fraction of pollutants.
2. Removal of sediment and buoyant materials. Nutrients, heavy metals, toxic materials, and oxygen-demanding particles are also removed with sediment substances associated with the particles.
3. Can be designed for combined flood control and stormwater quality control.
4. Requires less capital cost and land area when compared to wet pond BMP.
5. Downstream channel protection when properly designed and maintained.

LIMITATIONS

1. Require sufficient area and hydraulic head to function properly.
2. Generally not effective in removing dissolved and finer particulate size pollutants from stormwater.
3. Some constraints other than the existing topography include, but are not limited to, the location of existing and proposed utilities, depth to bedrock, location and number of existing trees, and wetlands.
4. Extended/dry detention basins have moderate to high maintenance requirements.
5. Sediments can be resuspended if allowed to accumulate over time and escape through the hydraulic control to downstream channels and streams.
6. Some environmental concerns with using extended/dry detention basins, include potential impact on wetlands, wildlife habitat, aquatic biota, and downstream water quality.
7. May create mosquito breeding conditions and other nuisances.

DESIGN CRITERIA

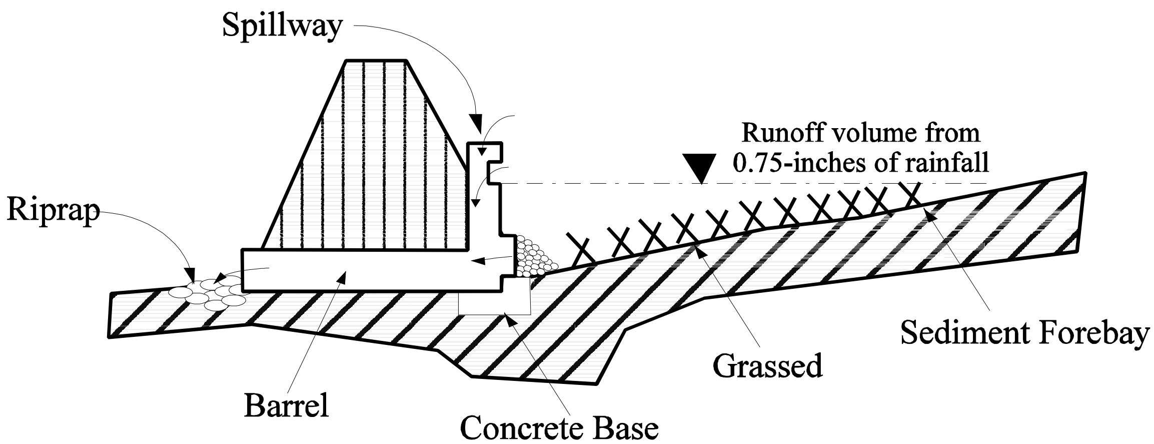


Figure 1. Conceptual elements of typical extended/dry detention structures.

Criteria	***Design Considerations***
Storage volume	Calculate the volume of stormwater to be mitigated by the extended/dry detention basin using the Los Angeles County Department of Public Works *Method for Calculating Standard Urban Stormwater Mitigation Plan (SUSMP) Flow Rates and Volumes Based on 0.75-inches of Rainfall*. Provide a storage volume for 120 percent of the runoff volume generated from 0.75-inches of rainfall above the lowest outlet in the basin. The additional 20 percent of storage volume provides for sediment accumulation and the resultant loss in storage volume.
Emptying time	A 24- to 48-hour emptying time should be used for the runoff volume generated from 0.75-inches of rainfall, with no more than 50 percent of the 0.75-inches of rainfall being released in 12 hours.
Basin geometry	Shape the pond with a gradual expansion from the inlet and a gradual contraction toward the outlet, thereby limiting short circuiting. The basin length to width ratio should be not less than 4.
Two-stage design	A two-stage design with a lower frequency pool that fills often with frequently occurring runoff minimizes standing water and sediment deposition in the remainder of the basin can enhance water quality benefits. The bottom stage should store 10 to 25 percent of the runoff volume generated from 0.75-inches of rainfall.
Low-flow channel	Conveys low base flows from the forebay to the outlet. Erosion protection should be provided for the low-flow channel.
Basin side slopes	Slopes should be stable and gentle enough to limit rill erosion and facilitate maintenance access and needs. Side slopes should be no steeper than 4:1 (H:V), preferably flatter.

Inlet	Dissipate flow energy at basin's inflow point(s) to limit erosion and promote particle sedimentation.
Forebay design	Provide the opportunity for larger particles to settle out in an area that has, as a useful refinement, a solid surface bottom to facilitate mechanical sediment removal. The forebay volume should be 5 to 10 percent of the runoff volume generated from 0.75-inches of rainfall.
Outlet design	Use a water quality outlet that is capable of slowly releasing the runoff volume generated from 0.75-inches of rainfall over a 24- to 48-hour period. A perforated riser can be used in conjunction with orifices and a weir box opening above it to control larger storm outflows. A cutoff collar should be considered for the outlet pipe to control seepage.
Perforation protection	Provide a crushed rock blanket of sufficient size to prevent clogging of the primary water quality outlet while not interfering significantly with its hydraulic capacity.
Dam embankment	The embankment should be designed not to fail during a 100-yr and larger storm. Embankment slopes should be no steeper than 3:1 (H:V), preferably 4:1, and flatter, and planted with turf-forming grasses. Poorly compacted native soils should be excavated and replaced. Embankment soils should be compacted to at least 95 percent of their maximum density. Spillway structures and overflows should be designed in accordance with local drainage criteria.
Vegetation	Bottom vegetation provides erosion control and sediment entrapment. Basin bottom, berms, and side-sloping areas may be planted with native grasses or with irrigated turf, depending on the local setting.
Maintenance access	Access to the forebay and outlet area shall be provided to maintenance vehicles. Maximum grades should be eight percent, and a solid driving surface of gravel, rock, concrete, or gravel-stabilized turf should be provided.

REFERENCES

1. Camp, Dresser and McKee, Inc., Larry Walker Associates, 1993. *California Best Management Practices - Municipal*, California State Water Resources Council Board, Alameda, CA.

2. GKY and Associates, Inc. June 1996. *Evaluation and Management of Highway Runoff Water Quality*, Publication No. FHWA-PD-96-032. Prepared for: US Department of Transportation, Federal Highway Administration. Washington, DC.

3. K. H. Lichten, June 1997. *Compilation of New Development Stormwater Treatment Controls in the San Francisco Bay Area*, Bay Area Stormwater Management Agencies Association, San Francisco, CA.

4. *Low-Impact Development Design Manual*, November 1997. Department of Environmental Resources, Prince George's County, MD.

5. T. R. Schueler, 1987. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs*, Department of Environmental Programs, Metropolitan Washington Council of Governments, Washington, DC.

6. Ventura Countywide Stormwater Quality Management Program, *Draft BMP DD: Extended Dry Detention Basins*, June 1999. Ventura, CA.

7. G. K. Young and F. Graziano, 1989. *Outlet Hydraulics of Extended Detention Facilities*, Northern Virginia Planning District Commission, Annandale, VA.

The following is a list of known locations where an Extended Dry Detention Basin was installed. The design of the installed basin in each location may vary from what is recommended in this SUSMP due to its specific circumstances. Los Angeles County does not endorse nor warranty any design used in the locations herein. Each individual case may require that the design be tailored to perform properly.

Installed Location (City/Address)	**Brand/Manufacturer**	**Owner/Client**
I-5/I-605 Intersection	N/A	Caltrans
I-605/SR 91 Intersection	N/A	Caltrans

B.7 INFILTRATION BASINS

DESCRIPTION

An infiltration basin is a surface pond which captures first-flush stormwater and treats it by allowing it to percolate into the ground and through permeable soils. As the stormwater percolates into the ground, physical, chemical, and biological processes occur which remove both sediments and soluble pollutants. Pollutants are trapped in the upper layers of the soil, and the water is then released to groundwater. Infiltration basins are generally used for drainage areas between 5 and 50 acres (Boutiette and Duerring, 1994). For drainage areas less than 5 acres, an infiltration trench or other BMP may be more appropriate. For drainage areas greater than 50 acres, maintenance of an infiltration basin would be burdensome, and an extended/dry detention basin or wet pond may be more appropriate. Infiltration basins are generally dry except immediately following storms, but a low-flow channel may be necessary if a constant base flow is present.

Infiltration basins create visible surface ponds that dissipate because water is infiltrated through the pond bottom; infiltration trenches hide surface drainage in underground void regions and the water is infiltrated below the rocks. Infiltration basins effectively remove soluble pollutants because processes such as adsorption and biological processes remove these soluble pollutants from stormwater. This kind of treatment is not always available in other kinds of BMPs.

Several types of infiltration basins exist. They can be either in-line or off-line, and may treat different volumes of water, such as the water quality volume or the 2-year or 10-year storm. A full infiltration basin is built to hold the entire water quality volume, and the only outlet from the pond is an emergency spillway. More commonly used is the combined infiltration/detention basin, where the outflow is controlled by a vertical riser. Excess flow volume spills over the drop inlet at the top of the riser, and very large storms will exit through the emergency spillway. Other types of basins include the side-by-side basin, and the off-line infiltration basin. The side by side basin consists of a basin with an elevated channel to carry base flows running along one of its sides. Storm flows also flow through the elevated channel, but overflow the channel and enter the basin when they become deep enough. An off-line infiltration basin is used to treat the first flush runoff, while higher flows remain in the main channel.

ADVANTAGES

1. High removal capability for particulate pollutants and moderate removal for soluble pollutants.
2. Groundwater recharge helps to maintain dry-weather flows in streams.
3. Can minimize increases in runoff volume.

4. When properly designed and maintained, it can replicate pre-development hydrology more closely than other BMP options.
5. Basins provide more habitat value than other infiltration systems.

LIMITATIONS

1. High failure rate due to clogging and high maintenance burden.
2. Low removal of dissolved pollutants in very coarse soils.
3. Not suitable on fill slopes or steep slopes.
4. Risk of groundwater contamination in very coarse soils, may require groundwater monitoring.
5. Should not be used if significant upstream sediment load exists.
6. Slope of contributing watershed needs to be less than 20 percent.
7. Not recommended for discharge to a sole source aquifer.
8. Cannot be located within 100 feet of drinking water wells.
9. Metal and petroleum hydrocarbons could accumulate in soils to potentially toxic levels.
10. Relatively large land requirement.
11. Only feasible where soil is permeable and there is sufficient depth to bedrock and water table.
12. Need to be located a minimum of 10 feet down gradient and 100 feet up gradient from building foundations because of seepage problems.
13. Infiltration facilities could fall under Chapter 15, Title 23, of California Code of Regulations regarding waste disposal to land.

DESIGN CRITERIA

Designing an infiltration basin is a process in which several factors are examined. The soil type and the drainage area are important factors in infiltration basin design. If either one of these two is inappropriate, the infiltration basin will not function properly. The steps in the design of an infiltration basin are listed below.

1. *Drainage Area.* Drainage areas between 5 and 50 acres are good candidates for infiltration basins. Infiltration trenches might be more appropriate for smaller drainage areas, while retention ponds are more appropriate for larger drainage areas (Schueler, 1987).
2. *Soils.* The site must have the appropriate soil, or the basin will not function properly. It is important that the soil be able to accept water at a minimum infiltration rate. Soils with an infiltration rate of less than 0.3 inches per hour, are not suitable sites for infiltration basins. Soils with a high percentage of clay are also undesirable, and should not be used if the percentage of clay is greater than 30. Generally, areas with fine to moderately fine soils are prevalent should not be

considered as sites, because these soils do not have a high infiltration rate. Soils with greater than 40 percent combined silt/clay also should not be used. A series of soil cores should be taken to a depth of at least 5 feet below the proposed basin floor elevation to determine which kinds of soils are prevalent at the potential site.

3. *Volume.* Calculate the volume of stormwater to be mitigated by the infiltration basin using the Los Angeles County Department of Public Works *Method for Calculating Standard Urban Stormwater Mitigation Plan (SUSMP) Flow Rates and Volumes Based on 0.75-inches of Rainfall*.
4. *Slope.* The basin floor should be as flat as possible to ensure an even infiltration surface and should not be or greater than 5 percent slope. Also, side slopes should have a maximum slope of 3 horizontal to 1 vertical (Schueler, 1987).
5. *Vegetation.* Vegetation should be established as soon as possible. Water-tolerant reed canary grass or tall fescue should be planted on the floor and side slopes of the basin (Schueler, 1987). Root penetration and thatch formation maintains and sometimes improves infiltration capacity of the basin floor. Also, the vegetation helps to trap the pollutants by growing through the accumulated sediment and preventing resuspension. The vegetation also helps reduce pollution levels by taking up soluble nutrients for growth and converting them into less available pollutant forms.
6. *Inlet.* Sediment forebays or riprap aprons should be installed to reduce flow velocities and trap sediments upon entrance to the basin. Flow should be evenly distributed over the basin floor by a riprap apron. The inlet pile or channel should enter the basin at floor level to prevent erosion (Schueler, 1987).
7. *Drainage Time.* The basin should completely drain within 24 hours to avoid the risk of it not being empty before the next storm. Overestimation of the future infiltration capacity can result in a standing water problem. Ponds with detention times of less than six hours are not effectively removing pollutants from the storm flows (Schueler, 1987). The most common problem is setting the elevation and size of the low-flow orifice. If the orifice is too large, runoff events pass through the basin too quickly. If the low-flow orifice diameter is too narrow, there is a risk of creating an undesirable quasi-permanent pool.
8. *Buffer Zone.* A 25 foot buffer should be placed between the edge of the basin floor, and the nearest adjacent lot (Schueler, 1987). The buffer should consist of water tolerant, native plant species that provide food and cover for wildlife. This buffer zone may also act as a screen if necessary.
9. *Access.* Access to the basin floor should be provided for light equipment (Schueler, 1987).
10. *Water Table.* The basin floor should be a minimum of 10 feet above the water table.
11. *Maximum Depth.* The maximum allowable depth is equal to the infiltration rate multiplied by the maximum allowable dewatering time (24 hours).
12. *Freeboard.* A minimum of 2 feet of freeboard should be available between the

spillway crest and the top of the dam (Dormann, et al., 1988).

13. *Emergency Spillway.* The emergency spillway should be able to safely pass the 100-year flood.
14. *Surface Area of the Basin Floor.* If the surface area of the basin floor is increased, the infiltration rate and quantity of runoff which can be infiltrated will be increased. Larger surface areas can also help compensate for clogging on the surface.

REFERENCES

1. L. N. Boutiette and C. L. Duerring, 1994. *Massachusetts Nonpoint Source Management Manual, The Megamanual: A Guidance Document for Municipal Officials*, Massachusetts Department of Environmental Protection, Office of Watershed Management, Nonpoint Source Program, Boston, MA.

2. Camp, Dresser and McKee, Inc., Larry Walker Associates, 1993. *California Best Management Practices - Municipal*, California State Water Resources Council Board, Alameda, CA.

3. M. E. Dormann, J. Hartigan, and B. Maestri, 1988. *Retention, Detention, and Overland Flow for Pollutant Removal from Highway Stormwater Runoff: Interim Guidelines for Management Measures*, FHWA/RD-87/056, Federal Highway Administration, Versar, Inc., Springfield, VA.

4. GKY and Associates, Inc. June 1996. *Evaluation and Management of Highway Runoff Water Quality*, Publication No. FHWA-PD-96-032. Prepared for: US Department of Transportation, Federal Highway Administration. Washington, DC.

5. T. R. Schueler, 1987. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs*, Department of Environmental Programs, Metropolitan Washington Council of Governments, Washington, DC.

6. Ventura Countywide Stormwater Quality Management Program, *Draft BMP IN: Infiltration Facilities*, June 1999. Ventura, CA.

The following is a known location where an Infiltration Basin was installed. The design of the installed basin in the location may vary from what is recommended in this SUSMP due to its specific circumstances. Los Angeles County does not endorse nor warranty any design used in the location herein. Each individual case may require that the design be tailored to perform properly.

Installed Location (City/Address)	Brand/Manufacturer	Owner/Client
I 605/SR 91	N/A	Caltrans

B.8 INFILTRATION TRENCHES

DESCRIPTION

An infiltration trench is basically an excavated trench that has been lined with filter fabric and backfilled with stone to form an underground basin. Runoff is diverted into the trench and either infiltrates into the soil, or enters a perforated pipe underdrain and is routed to an outflow facility. The depths of an infiltration trench generally range between 3 and 8 feet (Schueler, 1987) and may change when site-specific factors are considered. Smaller trenches are used for water quality, while larger trenches can be constructed if stormwater quantity control is required (Schueler, 1987). Trenches are not usually feasible in ultra-urban or retrofit situations where the soils have low permeability or low voids (Schueler, 1992). They should be installed only after the contributing area has stabilized to minimize runoff of sediments.

Infiltration trenches and infiltration basins follow similar design logic. The differences are that the former is for small drainage areas and stores runoff out of sight, within a gravel or aggregate matrix, whereas the latter is for larger drainage areas and water is stored in a visible surface pond.

Infiltration trenches effectively remove soluble and particulate pollutants. They can provide groundwater recharge by diverting 60 to 90 percent of annual urban runoff back into the soil (Boutiette and Duerring, 1994). They are generally used for drainage areas less than 10 acres, but some references cite 5 acres as a maximum size drainage area (Schueler, 1987, 1992). Potential locations include residential lots, commercial areas, parking lots, and adjacent to road shoulders. Trenches are only feasible on permeable soils (sand and gravel), and where the water table and bedrock are situated well below the bottom of the trench (Boutiette and Duerring, 1994; Schueler, 1987). Trenches are frequently used in combination with grassed sales. Trenches should not be used to trap course sediments, because the large sediment will clog the trench. Grass buffers can be installed to capture sediment before it enters the trench.

ADVANTAGES

1. Provides groundwater recharge.
2. Trenches fit into small areas.
3. Good pollutant removal capabilities.
4. Can minimize increases in runoff volume.
5. Can fit into medians, perimeters, and other unused areas of a development site.
6. Helps replicate pre-development hydrology and increases dry weather baseflow.

LIMITATIONS

1. Slope of contributing watershed needs to be less than 20 percent.
2. Soil should have infiltration rate greater than 0.3 inches per hour and clay content less than 30 percent.
3. Drainage area should be between 1 to 10 acres.
4. The bottom of infiltration trench should be at least 4 feet above the underlying bedrock and the seasonal high water table.
5. High failure rates of conventional trenches and high maintenance burden.
6. Low removal of dissolved pollutants in very coarse soils.
7. Not suitable on fill slopes or steep slopes.
8. Risk of groundwater contamination in very coarse soils, may require groundwater monitoring.
9. Infiltration facilities could fall under Chapter 15, Title 23, of California Code of Regulations regarding waste disposal to land.
10. Cannot be located within 100 feet of drinking water wells.
11. Need to be located a minimum of 10 feet down gradient and 100 feet up gradient from building foundations because of seepage problems.
12. Should not be used if upstream sediment load cannot be controlled prior to entry into the trench.
13. Metals and petroleum hydrocarbons could accumulate in soils to potentially toxic levels.

DESIGN CRITERIA

Infiltration trenches can be categorized both by trench type, and as surface or below ground. Special inlets are required for underground trenches to prevent sediment and oil or grease from clogging the infiltration trench (Schueler, 1987). Surface trenches are commonly used where land is not limiting and underground trenches are better suited for development with minimal land availabilities.

1. *Volume.* Calculate the volume of stormwater to be mitigated by the infiltration trench using the Los Angeles County Department of Public Works *Method for Calculating Standard Urban Stormwater Mitigation Plan (SUSMP) Flow Rates and Volumes Based on 0.75-inches of Rainfall*.
2. *Dimensions.* Generally, soils with low infiltration rates require a higher ratio of bottom surface area to storage volume (Northern Virginia Planning District Commission and Engineers and Surveyors Institute, 1992). The following formulas can be used to determine the dimensions of the infiltration basin:

$$H_{Tmax} = \frac{E \times t_{max}}{P}$$

$$H_{Tmin} = \frac{E \times t_{min}}{P}$$

$$A = \frac{V}{E \times t_{max}}$$

Where:

H_{Tmax}, H_{Tmin}	=	Maximum and minimum trench depths (ft).
E	=	Infiltration rate in length per unit time (ft/hr).
t_{max}, t_{min}	=	Maximum and minimum target drain-time (hr).
P	=	Pore volume ratio of stone aggregate (% porosity/100).
V	=	Fluid storage volume requirement (ft^3).
A	=	Trench bottom surface area (ft^2).

The actual storage volume of the facility is the void ratio multiplied by the total volume of the trench. The available land and other constraints such as depth to bedrock or water table are used to determine the final dimensions of the trench.

3. *Buffer Strip/Special Inlet.* A grass filter strip a minimum of 20 feet should surround the trench on all sides over which surface flow reaches an above-ground trench. A special inlet can be used to prevent floatable material, solids, grease, and oil from entering trenches which are located below ground.
4. *Filter Fabric.* The bottom and sides of the trench should be lined with filter fabric soon after the trench is excavated. The fabric should be flush with the sides, overlap on the order of 2 feet over the seams, and not have trapped air pockets. As an alternative, 6 inches of clean, washed sand may be placed on the bottom of the trench instead of filter fabric.
5. *Grass Cover.* If the trench is grass covered, at least 1 foot of soil should be over the trench for grass substrate.
6. *Surface Area.* The surface area of the trench can be engineered to the site with the understanding that a larger surface area of the bottom of the trench increases infiltration rates and helps to reduce clogging and that depth may be limited by

seasonal groundwater.

7. *Surface Area of the Trench Bottom.* Pollutant removal in a trench can be improved by increasing the surface area of the trench bottom. This is done by adjusting the geometry to make the trench shallow and broad, rather than deep and narrow. Greater bottom surface area increases infiltration rates and provides more area and depth for soil filtering. In addition, broader trench bottoms reduce the risk of clogging at the soil/filter cloth interface by spreading infiltration over a wider area.
8. *Distance from Wells and Foundations.* The trench should be at least 100 feet of any drinking water supply well, and at least 10 feet downgradient and 100 feet upgradient from building foundations (Schueler, 1987).
9. *Drain Time.* The drain time should be between two and three days. The total volume of the trench should drain in 48 hours. The minimum drain time should be 24 hours.
10. *Backfill Material.* The backfill material in the trench should have a D_{50} sized between 1.5 and 3 inches and clay content should be limited to less than 30 percent. The porosity of the material should be between 0.3 and 0.4.
11. *Observation Well.* An observation well of 4 to 6 inches diameter PVC should be located in the center of the trench and the bottom should rest on a plate. The top should be capped. The water level should be measured after a storm event. If it has not completely drained in three days, some remedial work may need to be done.
12. *Overflow Berm.* A 2 to 3 inch emergency overflow berm on the downstream side of the trench serves a twofold purpose. First, it detains surface runoff and allows it to pond and infiltrate to the trench. The berm also promotes uniform sheet flow for runoff overflow.

V. REFERENCES

1. L. N. Boutiette and C. L. Duerring, 1994. *Massachusetts Nonpoint Source Management Manual, The Megamanual: A Guidance Document for Municipal Officials*, Massachusetts Department of Environmental Protection, Office of Watershed Management, Nonpoint Source Program, Boston, MA.

2. Camp, Dresser and McKee, Inc., Larry Walker Associates, 1993. *California Best Management Practices - Municipal*, California State Water Resources Council Board, Alameda, CA.

3. DEQ Storm Water Management Guidelines, Department of Environmental Quality, State of Oregon. http://waterquality.deq.state.or.us/wq/groundwa/swmgmtguide.htm

4. M. E. Dormann, J. Hartigan, and B. Maestri, 1988. *Retention, Detention, and Overland Flow for Pollutant Removal from Highway Stormwater Runoff: Interim Guidelines for Management Measures*, FHWA/RD-87/056, Federal Highway Administration, Versar, Inc., Springfield, VA.

5. GKY and Associates, Inc. June 1996. *Evaluation and Management of Highway Runoff Water Quality*, Publication No. FHWA-PD-96-032. Prepared for: US Department of Transportation, Federal Highway Administration. Washington, DC.

6. *Low-Impact Development Design Manual*, November 1997. Department of Environmental Resources, Prince George's County, MD.

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9. T. R. Schueler, P. Kumble, and M. Heraty, 1992. *A Current Assessment of Urban Best Management Practices: Techniques for Reducing Nonpoint Source Pollution in the Coastal Zone*, Anacostia Research Team, Metropolitan Washington Council of Governments, Washington, DC.

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B.9 MEDIA FILTRATION

DESCRIPTION OF SAND FILTERS

Media filters are two-stage constructed treatment systems, including a pretreatment settling basin and a filter bed containing sand or other filter media. Various types of sand filter designs have been developed and implemented successfully in space-limited areas. The filters are not designed to treat the entire storm volume but rather the water quality volume (WQV), that tends to contain higher pollutant levels. The WQV represents the site runoff volume generated from 0.75-inches of rainfall. Sand filters can be designed so that they receive flow directly from the surface (via inlets or even as sheet flow directly onto the filter bed) or via storm drain pipes. They can be exposed to the surface or completely contained in underground pipe systems or vaults.

While there are various designs, most intermittent sand filters contain four basic components, as shown schematically in Figure 1 and discussed below:

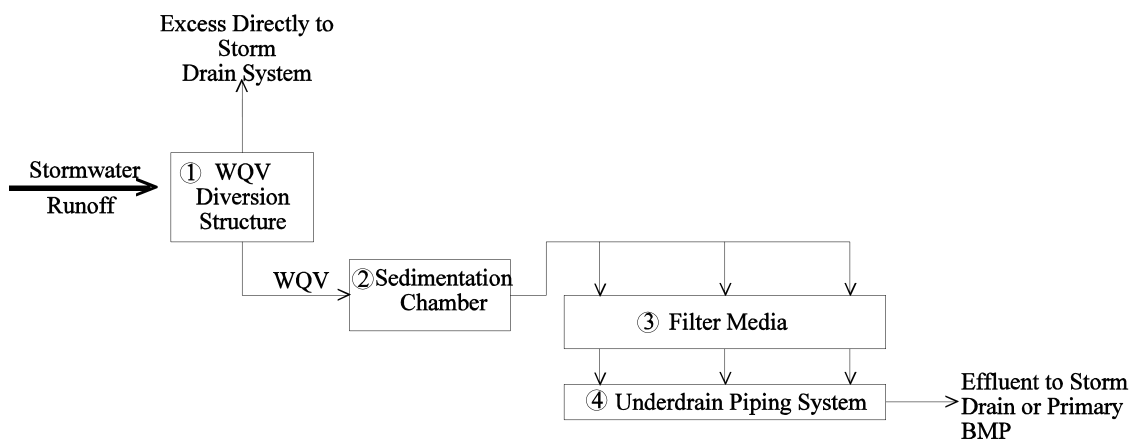

Figure 1. Schematic of a typical sand filter.

1. *Diversion Structure.* Either incorporated into the filter itself or as a stand alone

device, the diversion structure isolates the WQV and routes it to the filter. Larger volumes are bypassed directly to the storm drain system.

2. *Sedimentation Chamber.* Important to the long-term successful operation of any filtration system is the removal of large grained sediments prior to exposure to the filter media. The sedimentation chamber is typically integrated directly into the sand filter BMP but can also be a stand alone unit if space permits.
3. *Filter Media.* Typically consists of a 1-inch gravel layer over an 18 to 24 inch layer of washed sand. A layer of geotextile fabric can be placed between the gravel and sand layers.
4. *Underdrain System.* Below the filter media is a gravel bed, separated from the sand by a layer of geotextile fabric, in which is placed a series of perforated pipes. The treated runoff is routed out of the BMP to the storm sewer system or another BMP.

ADVANTAGES

1. May require less space than other treatment control BMPs and can be located underground.
2. Does not require continuous base flow.
3. Suitable for individual developments and small tributary areas up to 100 acres.
4. Does not require vegetation.
5. Useful in watersheds where concerns over groundwater quality or site conditions prevent use of infiltration.
6. High pollutant removal capability.
7. Can be used in highly urbanized settings.
8. Can be designed for a variety of soils.
9. Ideal for aquifer regions.

LIMITATIONS

1. Given that the amount of available space can be a limitation that warrants the consideration of a sand filter BMP, designing one for a large drainage area where there is room for more conventional structures may not be practical.
2. Available head to meet design criteria.
3. Requires frequent maintenance to prevent clogging.
4. Not effective at removing liquid and dissolved pollutants.
5. Severe clogging potential if exposed soil surfaces exist upstream.
6. Sand filters may need to be placed offline to protect it during extreme storm events.

DESIGN CRITERIA

1. *Volume.* Calculate the flow rate of stormwater to be mitigated by the media filtration

system using the Los Angeles County Department of Public Works *Method for Calculating Standard Urban Stormwater Mitigation Plan (SUSMP) Flow Rates and Volumes Based on 0.75-inches of Rainfall*.

2. *Surface area of the filter.* The following equation is for a maximum filtration time of 24 hours:

A. Surface Systems or Vaults

Filter area (ft^2) = $3630 S_u AH/K(D+H)$

Where:
- S_u = unit storage (inches-acre)
- A = area in acres draining to facility
- H = depth (ft) of the sand filter
- D = average water depth (ft) over the filter taken to be one-half the difference between the top of the filter and the maximum water surface elevation
- K = filter coefficient recommended as 3.5

This equation is appropriate for filter media sized at a diameter of 0.02 to 0.04 inches. The filter area must be increased if a smaller media is used.

B. Underground Sandfilter Systems

a. Compute the required size of the sand filter bed surface area, A_F. The following equation is based on Darcy's law and is used to size the sand filter bed area:

A_F (ft^2) = $24(WQV)(d_f)/ [k (h_f + d_f) t_f]$

Where:
- A_f = sand filter bed surface area (ft^2)
- WQV = Water quality treatment volume (ft^3)
- d_f = sand filter bed depth (ft)
- k = filter coefficient recommended as 3.5 (ft/day)
- h_f = average height of water above the sand bed (ft) = $h_{max}/2$
- h_{max} = elevation difference between the invert of the inlet pipe and the top of the sand filter bed (ft)
- t_f = time required for the runoff to filter through the sand bed (hr). (Typically 24 hr).

Note: 24 in the equation is the 24hr/day constant.

b. Choose a pipe size (diameter). The selection of pipe size should be based on site parameters such as: elevation of the runoff coming into the sand filter system, elevation of downstream connection to which the sand filter system outlet must tie into, and the minimum cover requirements for live loads. A minimum of 5' clearance should be provided between the top of the inner pipe wall and the top of the filter media for maintenance purpose. Use:

$D = d + 5$

Where: D = pipe diameter (ft)
d = depth of sand filter and underdrain pipe media depth (ft)
= $d_g + d_f$
d_g = underdrain pipe media depth = 0.67'
d_f = sand filter bed deph (ft): 1.5 to 2.0 feet

c. Compute the sand filter width(based on the pipe geometry):

$W_f = 2\,[R^2 - (R - d)^2\,]^{0.5}$

Where: W_f = filter width (ft)
R = pipe radius (ft)
= D/2

d. Compute the filter length:

$L_f = A_f / W_f$

Where: L_f = filter length (ft)

3. *Configuration*

A. Surface sand filter

Criteria for the settling basin.

a. For the outlet use a perforated riser pipe.
b. Size the outlet orifice for a 24 hour drawdown
c. Energy dissipator at the inlet to the settling basin.
d. Trash rack at outlets to the filter.
e. Vegetate slopes to the extent possible.
f. Access ramp (4:1 or less) for maintenance vehicles.
g. One foot of freeboard.
h. Length to width ratio of at least 3:1 and preferably 5:1.

i. Sediment trap at inlet to reduce resuspension.

Criteria for the filter.

a. Use a flow spreader.
b. Use clean sand 0.02 to 0.04 inch diameter.
c. Some have placed geofabric on sand surface to facilitate maintenance.
d. Underdrains with:
   - Schedule 40 PVC.
   - 4 inch diameter.
   - 3/8 inch perforations placed around the pipe, with 6 inch space between each perforation cluster.
   - maximum 10 foot spacing between laterals.
   - minimum grade of 1/8 inch per foot.

B. Underground sand filter

Criteria for the settling tank (if required).

a. Use orifice and/or weir structure for the outlet.
b. Size the outlet orifice or weir for a 24 hour drawdown time
c. Provide access manhole for maintenance.

Criteria for the filter.

a. Use a flow spreader.
b. Use clean sand 0.02 to 0.04 inch diameter.
c. Some have placed geofabric on sand surface to facilitate maintenance.
d. Underdrains with:
   – Schedule 40 PVC.
   – 4 inch diameter
   – 3/8 inch perforations placed around the pipe, with 6 inch space between each perforation cluster.
e. Provide access manhole for maintenance.

REFERENCES

1. Camp, Dresser and McKee, Inc., Larry Walker Associates, 1993. *California Best Management Practices - Municipal*, California State Water Resources Council Board. Alameda, CA.

2. GKY and Associates, Inc. June 1996. *Evaluation and Management of Highway Runoff Water Quality*, Publication No. FHWA-PD-96-032. Prepared for: US Department of Transportation, Federal Highway Administration. Washington, DC.

3. B. R. Urbonas, January/February 1999. *Design of a Sand Filter for Stormwater Quality Enhancement*, Water Environment Research, Volume 71, Number 1. Denver, CO.

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6. US EPA, Developments in Sand Filter Technology to Improve Runoff Quality, www.epa.gov/owowwtr1/NPS/wpt/wpt02/wpt02fa2.html.

The following is a list of known locations where a Media Filtration was installed. The design of the installed filter in each location may vary from what is recommended in this SUSMP due to its specific circumstances. Los Angeles County does not endorse nor warranty any design used in the locations herein. Each individual case may require that the design be tailored to perform properly.

Installed Location (City/Address)	**Brand/Manufacturer**	**Owner/Client**
Eastern Regional Maintenance Station	N/A	Caltrans
Foothill Maintenance Sta.	N/A	Caltrans
Termination Park & Ride	N/A	Caltrans
Paxton Park & Ride	N/A	Caltrans

B.10 POROUS PAVEMENT

DESCRIPTION

Porous pavement is an asphalt based paving material that allows stormwater to quickly infiltrate the surface pavement layer to enter into a high-void aggregate sub-base layer. The captured runoff is stored in this "reservoir" layer until it either infiltrates into the underlying soil strata or is routed through an underdrain system to a conventional stormwater conveyance system. Porous pavements operate in a similar fashion to infiltration trenches and thus provide similar water quality benefits. An example of a typical porous pavement system is shown in Figure 1.

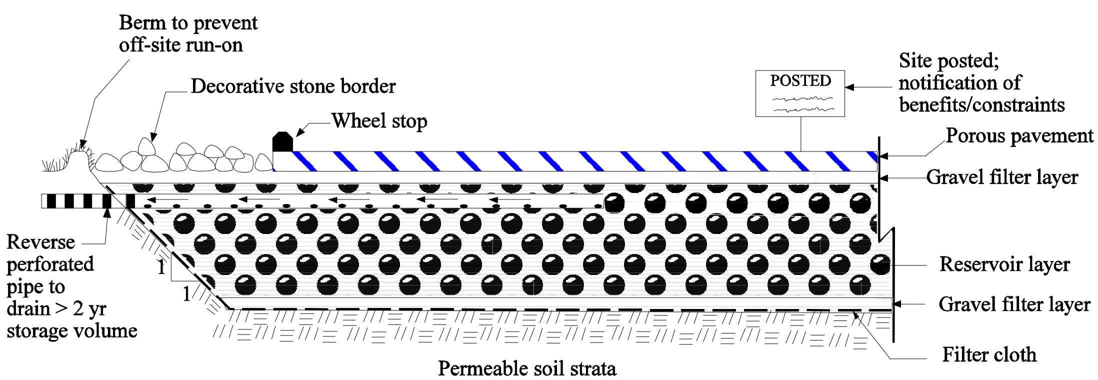

Figure 1. Schematic of porous pavement system.

ADVANTAGES

1, Porous pavements operate in a similar fashion to infiltration trenches and thus provide similar water quality benefits, including reductions in fine grained sediments, nutrients, organic matter, and trace metals.
2. In addition to water quality benefits, porous pavements also provide significant reductions in surface runoff with up to 90 percent of rainfall retained within the BMP (Schueler, 1992).
3. An added benefit provided by the on-site infiltration is the extent to which the stormwater runoff is able to contribute to groundwater recharge.
4. Reduces pavement ponding.

LIMITATIONS

1. Only applicable for low-traffic volume areas.
2. To maintain effectiveness, porous pavements require frequent maintenance.
3. Porous pavements are not intended to remove sediments.
4. Easily clogged by sediments if not situated properly.
5. Porous pavements are limited to treating small areas (0.25 to 10 acres).
6. Contributing drainage area slopes should be 5 percent or less to limit the amount of sediments that could potentially lead to clogging of the porous pavement.
7. On average, porous pavements clog within 5 years.
8. Underlying soil strata must have an adequate infiltration capacity of at least 0.3 inches per hour but preferably 0.50 in/hr or more. Adequate soil permeability should extend for a depth of at least 4 feet.
9. The bottom of the reservoir layer should be at least 4 feet above the seasonally high water table. Porous pavements should be no closer than 100 feet from drinking wells and 100 feet upgradient and 10 feet downgradient from building foundations. Due to the risk of groundwater contamination, porous pavements should not be used for gas stations or other areas with a relatively high potential for chemical spills. Similarly, special consideration should be given to the use of porous pavements in wellhead protection areas serviced by sole source aquifers.
10. The porous pavement should not be located where run-on from adjacent areas can introduce sediments to the pavement surface. Similarly, areas subject to wind-blown sediment loads should be avoided.
11. Extended rain can reduce the pavement’s load bearing capacity.
12. More expensive than traditional paving surfaces.

DESIGN CRITERIA

A water quality porous pavement system provides only enough storage volume to capture the “first flush” of the rainfall. The “first flush” is defined as the runoff volume generated from 0.75-inches of rainfall. Calculate the volume of stormwater to be mitigated by the porous pavement using the Los Angeles County Department of Public Works *Method for Calculating Standard Urban Stormwater Mitigation Plan (SUSMP) Flow Rates and Volumes Based on 0.75-inches of Rainfall*. The remaining storm volume bypasses the BMP and is routed to a conventional stormwater conveyance system.

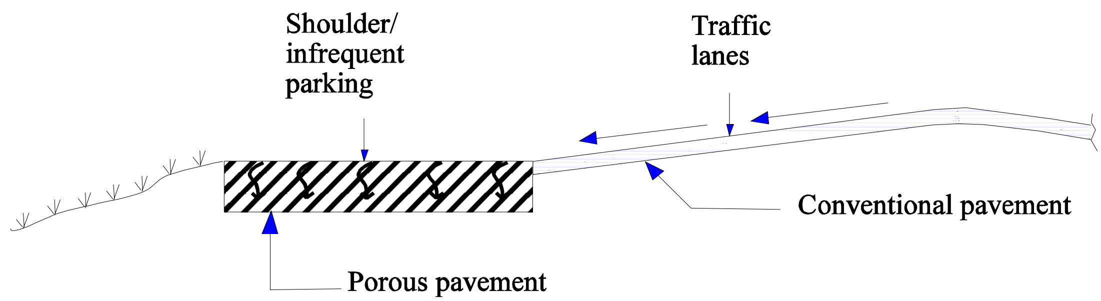

Figure 2. Schematic of a combination conventional/porous pavement system.

1. The prediction of the rate of infiltration of water through natural soils is related to soil type, porosity, degree of compaction, moisture content, and field capacity. This complexity governs soil drain times and has made the development of a single comprehensive model to predict drain times in actual porous pavement applications difficult. However, determining drain time is the key element in designing the size of porous pavement systems. The depth of the sub-base can be determined by:

$$H_d = \frac{E \times t_d}{r}$$

Where:

H_d	=	Depth of reservoir layer (in).
t_d	=	Detention time (hr).
E	=	Soil infiltration rate (in/hr).
r	=	Void ratio.

The required porous pavement surface area can then be computed by:

$$A_s = \frac{V}{r \times H_d}$$

Where:

A_s	=	Porous pavement surface area (ft^2).
V	=	Water quality volume (ft^3).

Table 1 provides the required amount of porous pavement surface area per acre and the depth of the reservoir layer with the assumption that the area is completely impervious. Also assumed is that the void ratio is 0.4, typical value, and the detention time is 48 hours.

Table 1. Using a void ratio (r) of 0.4 and a detention time (t_d) of 48 hours the following porous pavement surface area and depth of reservoir layer that is required for the respective infiltration rates.

Soil infiltration rate E (in/hr)	Depth of reservoir layer H_d (feet)	Porous pavement surface area per acre A_s ($feet^2$)
0.27	2.7	2,521
0.30	3.0	2,269
0.35	3.5	1,945
0.40	4.0	1,702
0.45	4.5	1,513
0.50	5.0	1,361
0.55	5.5	1,238
0.60	6.0	1,134
0.65	6.5	1,047
0.70	7.0	972
0.75	7.5	908
0.80	8.0	851
0.85	8.5	801
0.90	9.0	756
0.95	9.5	716
1.00	10.0	681

2. *Specifications.* The cross-section typically consists of four layers, as shown in Figure 3. Descriptions of each of the layers is presented below.
3. *Asphalt Layer* - The surface asphalt layer consists of an open-graded asphalt mixture ranging from depths of 2 to 4 inches depending on required bearing strength and pavement design requirements. Porous pavements contain

approximately 16 percent voids, compared to 3 to 5 percent for conventional pavements, allowing runoff to quickly infiltrate. A recommended gradation specification for an open-graded aggregate mixture is presented in Table 2.

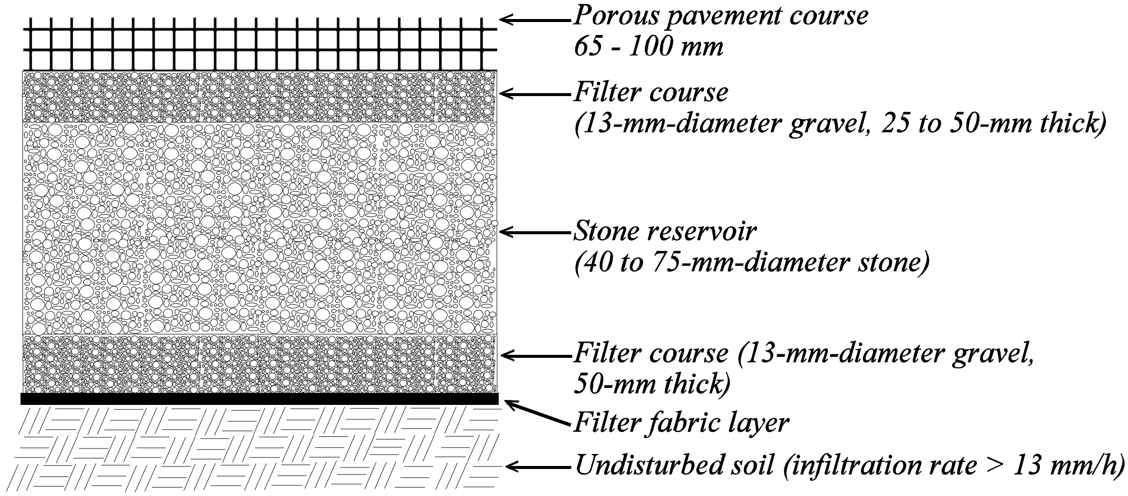

Figure 3. Schematic of typical porous pavement section.

Table 2. Aggregate gradation for porous pavement.

U.S. Sieve Series Size	*Opening (mm)*	*Percent Passing by Weight*
½ in	12.70	100
3/8 in	9.51	95-100
#4	4.76	30-50
#8	2.38	5-15
#200[1]	0.074	2-5

Note : 1. Aggregate should be uniformly graded between #8 and #200 sieve.

4. *Top Filter Layer.* Consists of a 0.5 inch diameter crushed stone to a depth of 1 to 2 inches. This layer serves to stabilize the porous asphalt layer. Table 2

provides typical details on gradation standards and specifications.

5. *Reservoir Layer.* The reservoir sub-base consists of 1.5 to 3 inches crushed stone. The depth of this layer depends on the desired storage volume, which is a function of the soil infiltration rate, void spaces, and, in colder climates, the depth of the frost line, but typically ranges from 2 to 4 feet. The reservoir layer should be designed to drain completely in 48 to 72 hours. Table 3 provides further details on standards and specifications.
6. *Bottom Filter Layer.* This layer serves to stabilize the reservoir layer and is the interface between the reservoir layer and the filter fabric covering the underlying soil. It consists of a 2 inch thick layer of 0.5 inch crushed stone. Table 3 provides further details on standards and specifications.
7. *Filter Fabric.* It is very important to line the entire trench area, including the sides, with filter fabric prior to placement of the aggregate. The filter fabric serves a very important function by inhibiting soil from migrating into the reservoir layer and reducing storage capacity. Table 3 provides further details on standards and specifications.
8. *Underlying Soil.* The underlying soil should have an infiltration capacity of at least 0.3 in/hr, but preferably greater than 0.50 in/hr. Soils at the lower end of this range may not be suited for a full infiltration system. Infiltration rates for several soil types are given in Table 3 (Yu and Kaighn, 1992).
9. *Construction Practices (adapted from Schueler, 1992).*
   (1) All adjacent areas should be stabilized to prevent any sediment from washing onto the pavement surface, leading to premature clogging.
   (2) The subgrade shall be prepared as required while limiting undue compaction; permeability must be maintained. Equipment with tracks or over-sized rubber tires shall be used; DO NOT use vehicles with standard rubber tires.
   (3) The reservoir base course shall be laid in lifts over the base filter course and lightly compacted. The base courses should be kept free of all dirt and debris during construction.
   (4) The asphalt layer shall be laid directly over the top filter course in one lift. The laying temperature should be between 240 and 260 °F. The ambient temperature should be above 50 °F.
   (5) Compaction should take place when the surface is cool enough to resist a 9-Mg roller (class equivalent of a 10-ton roller). One or two passes is all that is required for proper compaction. Any more may reduce porosity.
   (6) Transporting of the mix to the site shall be in clean vehicles with smooth dump beds that have been sprayed with a non-petroleum release agent. The mix should be covered during transport to limit cooling.
   (7) After final rolling, no vehicular traffic of any kind should be permitted on the pavement until cooling and hardening has taken place; no sooner than six hours but preferably a day or two.

Table 3. Standards and specifications for design of porous pavements.

Layer	*Thickness*	*Material*	*Specifications*	*Comments*
Pavement	51-102 mm	Open Graded Aggregate	ASTM D 693-77 *"Crushed Stone, Crushed Slag, and Crushed Gravel for Dry or Water-Bound Macadam Base and Surface Courses of Pavements"*	Two exceptions: 1) open graded. 2) soundness test required per ASTM D 692-79.
		Asphalt	Asphalt Grade: AASHTO M-20.	For 85 to 100 penetration road asphalt as a binder in the northern U. S., 65 to 80 in the middle States, and 50 to 65 in the southern States.
			Viscosity Grade: AC-20 AASHTO M-226-73 I.	Use as a starting point; may be altered as necessary.
			Stripping Resistance: ASTM D1664.	If estimated coating area is not above 95%, add anti-stripping agent to mix.
			Asphalt Content: 5.75-6 % of weight of dry aggregate; test using FHWA Report No. FHWA-RD-74-2.	
Gravel Filters/Reservoir	Top Filter: 25-51 mm	13-mm Dia. Aggregate	Local Highway Dept. Specifications for Crushed Stone.	All aggregates must be washed to remove fines to prevent clogging.
	Reservoir Layer: 0.61-1.21 m	25-76-mm Dia. Aggregate	Local Highway Dept. Specifications for Crushed Stone.	All aggregates must be washed to remove fines to prevent clogging.
	Bottom Filter: 51 mm	13-mm Dia. Aggregate	Local Highway Dept. Specifications for Crushed Stone.	All aggregates must be washed to remove fines to prevent clogging.
Filter Cloth	-	Filter Cloth	MIRIFI # 14 N or equivalent.	

Note: Adapted from Schueler, 1992.

Table 4. Soil types for porous pavement systems.

Soil Type	Minimum Infiltration Rate (mm/hr)	SCS Soil Group	Maximum Depth of Storage (m)[1]	
			48 hr Drain Time	72 hr Drain Time
Sand	210	A	25	15
Loamy Sand	61.2	A	7.4	4.4
Sandy Loam	25.9	B	3.1	4.6
Loam	13.2	B	1.6	2.4
Silt Loam	6.85	C	0.81	1.2

Note : 1. Maximum depth of storage that can be drained within the specified time.

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B.12 STORM DRAIN INSERTS

DESCRIPTION

Storm drain inserts can be a variety of devices that are used in storm drain conveyance systems to reduce pollutant loadings in stormwater runoff. Most storm drain inserts reduce oil and grease, debris, and suspended solids through gravity, centrifugal force, or other methods. BMPs such as these can be particularly useful in areas susceptible to spills of petroleum products, such as gas stations. Figures 1 and 2 illustrate one of many different types of storm drain inserts.

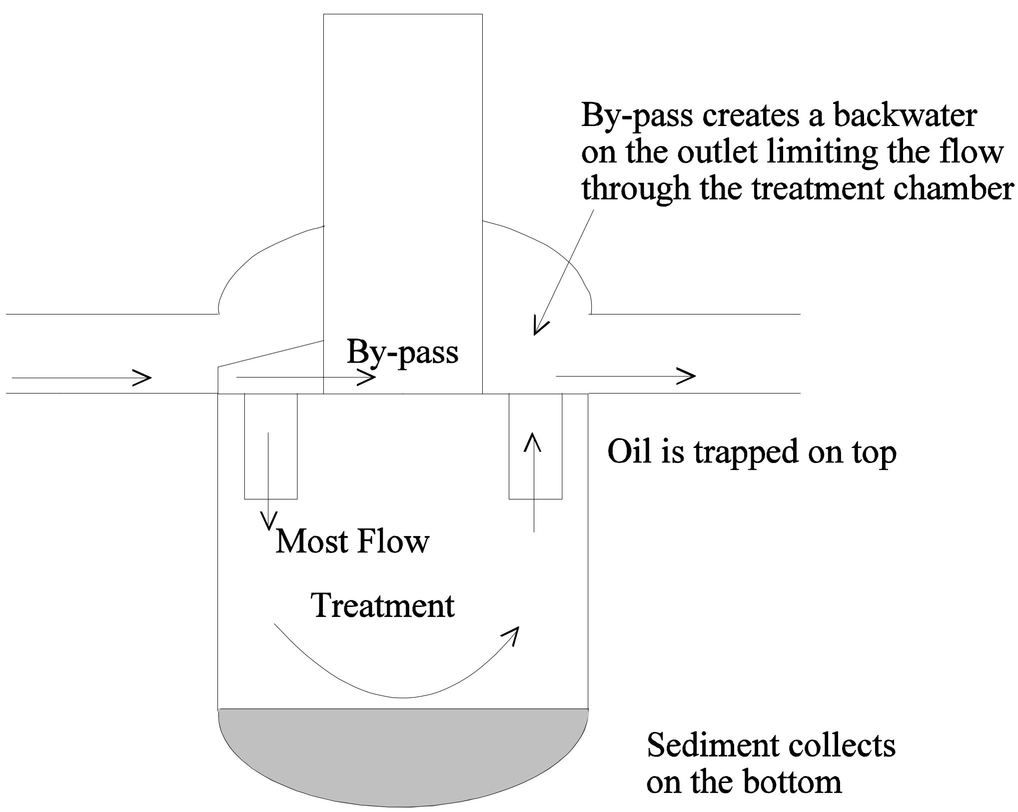

Figure 1. Typical configuration (side view).

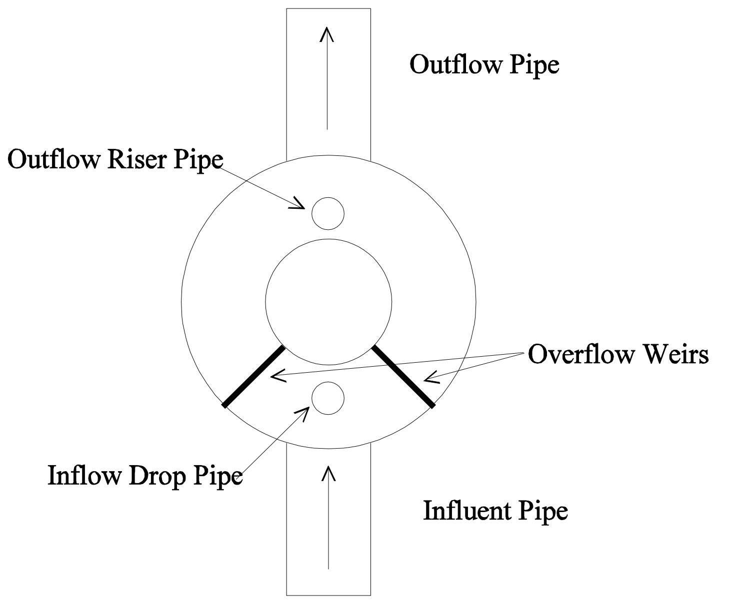

Figure 2. Typical configuration (top view).

Trapped sediments and floatable oils must be pumped out regularly to maintain the effectiveness of the units.

ADVANTAGES

1. Low installation costs.
2. Prefabricated for different standard storm drain designs.
3. Require minimal space to install.

LIMITATIONS

1. Some devices may be vulnerable to accumulated sediments being resuspended during heavy storms.
2. Can only handle limited amounts of sediment and debris.
3. Maintenance and inspection of storm drain inserts are required before and after each rainfall event.
4. High maintenance costs.
5. Hydraulic losses.

DESIGN CRITERIA

1. Calculate the flow rate or volume of stormwater to be mitigated by the storm drain insert using the Los Angeles County Department of Public Works *Method for Calculating Standard Urban Stormwater Mitigation Plan (SUSMP) Flow Rates and Volumes Based on 0.75-inches of Rainfall*.

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The following is a list of known locations where a Storm Drain Insert device was installed. The design of the installed device in each location may vary from what is recommended in this SUSMP due to its specific circumstances. Los Angeles County does not endorse nor warranty any design used in the locations herein. Each individual case may require that the design be tailored to perform properly.

Installed Location (City/Address)	Brand/Manufacturer	Owner/Client
I-210/Orcas Ave.	Not available	Caltrans
I-210/Filmore St.	Not available	Caltrans
Marina Del Rey: 13477 Fiji Way, L.A.	CDS (Continuous Deflective Separation Device)	Los Angeles County Beaches & Harbor
Santa Monica [1]	CDS Device	Los Angeles County Dept. of Public Works
Santa Monica	CDS Device	City of Santa Monica
Santa Clarita	CDS Device	City of Santa Clarita
Calabasas	CDS Device	City of Calabasas

[1] Not constructed yet.

B.12 VEGETATED FILTER STRIPS

DESCRIPTION

Vegetated filter strips, also known as vegetated buffer strips, are vegetated sections of land similar to grassed swales, except they are essentially flat with low slopes, and are designed only to accept runoff overland sheet flow (Schueler, 1992). They may appear in any vegetated form from grassland to forest, and are designed to intercept upstream flow, lower flow velocity, and spread water out as sheet flow (Schueler, 1992). The dense vegetative cover facilitates conventional pollutant removal through detention, filtration by vegetation, and infiltration into soil (Yu and Kaighn, 1992). Wooded and grass filter strips have slightly higher removal rates. Dissolved nutrient removal for either type of vegetative cover is usually poor, however wooded strips show slightly higher removal due to increased retention and sequestration by the plant community (Florida Department of Transportation, 1994).

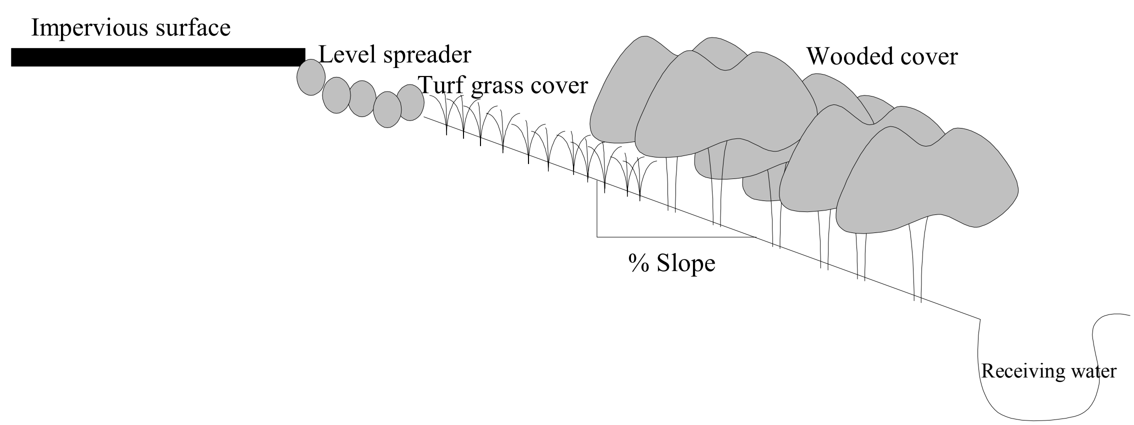

Figure 1. Conceptual design for a vegetated filter strip (Indiana County Conservation District)

Although an inexpensive control measure, they are most useful in contributing watershed areas where peak runoff velocities are low, as they are unable to treat the high flow velocities typically associated with high impervious cover (Barret, et al., 1993).

Similar to grassed swales, filter strips can last for 10 to 20 years with proper conditions and regular maintenance. Life expectancy is significantly diminished if uniform sheet flow and dense vegetation are not maintained.

ADVANTAGES

1. Lowers runoff velocity (Schueler, 1987).
2. Slightly reduces runoff volume (Schueler, 1987).
3. Slightly reduces watershed imperviousness (Schueler, 1987).
4. Slightly contributes to groundwater recharge (Schueler, 1987).
5. Aesthetic benefit of vegetated “open spaces” (Colorado Department of Transportation, 1992).
6. Preserves the character of riparian zones, prevents erosion along streambanks, and provides excellent urban wildlife habitat (Schueler, 1992).

LIMITATIONS

1. Filter strips cannot treat high velocity flows, and do not provide enough storage or infiltration to effectively reduce peak discharges to predevelopment levels for design storms (Schueler, 1992). This lack of quantity control dictates use in rural or low density development.
2. Requires slope less than 5%.
3. Requires low to fair permeability of natural subsoil.
4. Large land requirement.
5. Often concentrates water, which significantly reduces effectiveness.
6. Pollutant removal is unreliable in urban settings.

DESIGN CRITERIA

1. Successful performance of filter strips relies heavily on maintaining shallow unconcentrated flow (Colorado Department of Transportation, 1992). To avoid flow channelization and maintain performance, a filter strip should:

   (1) Be equipped with a level spreading device for even distribution of runoff,
   (2) Contain dense vegetation with a mix of erosion resistant, soil binding species,
   (3) Be graded to a uniform, even and relatively low slope,
   (4) Laterally traverse the contributing runoff area (Schueler, 1987),
   (5) The area to be used for the strip should be free of gullies or rills that can concentrate overland flow (Schueler, 1987),
   (6) Filters strip should be placed 3 to 4 feet from edge of pavement to accommodate a vegetation free zone (Washington State Department of Transportation, 1995). The top edge of the filter strip along the pavement should be designed to avoid the situation where runoff would travel along the top of the filter strip, rather than through it. Dilhalla, et al., (1986) suggest that berms be placed at 50 to 100 feet intervals perpendicular to the top edge of the strip to prevent runoff from bypassing it (as cited in

Washington State Department of Transportation, 1995),

(7) Top edge of the filter strip should follow the same elevational contour. If a section of the edge of the strip dips below the contour, runoff will tend to form a channel toward the low spot,

(8) Filter strips should be landscaped after other portions of the project are completed (Washington State Department of Transportation, 1995). However, level spreaders and strips used as sediment control measures during the construction phase can be converted to permanent controls if they can be regraded and reseeded to the top edge of the strip.

2. Filter strips can be used on an upgradient from watercourses, wetlands, or other water bodies, along toes and tops of slopes, and at outlets of other stormwater management structures (Boutiette and Duerring, 1994). They should be incorporated into street drainage and master drainage planning (Urbonas, 1992). The most important criteria for selection and use of this BMP are soils, space, and slope, where:

(1) *Soils and moisture are adequate to grow relatively dense vegetative stands.* Underlying soils should be of low permeability so that the majority of the applied water discharges as surface runoff. The range of desirable permeability is between 0.06 to 0.6 inches/hour (Horner, 1985). Common soil textural classes are clay, clay loam, and silty clay. The presence of clay and organic matter in soils improves the ability of filter strips to remove pollutants from the surface runoff (Schueler, 1992). Greater removal of soluble pollutants can be achieved where the water table is within 3 feet of the surface (i.e., within the root zone) (Schueler, 1992). Filter strips function most effectively where the climate permits year-round dense vegetation. They are not recommended in arid regions where vegetation in upland areas is sparse.

(2) *Sufficient space is available.* Because filter strip effectiveness depends on having an evenly distributed sheet flow, the size of the contributing area and the associated volume runoff have to be limited (Urbonas, 1992). To prevent concentrated flows from forming, it is advisable to have each filter strip serve a contributing area of five acres or less (Schueler, 1987). When used alone, filter strip application is in areas where impervious cover is low to moderate and where there are small fluctuations in peak flow.

(3) *Longitudinal slope is five percent or less.* When filter strips are used on steep or unstable slopes, the formation of rills and gullies can disrupt sheet flow (Urbonas, 1992). As a result filter strips will not function at all on slopes greater than 15 percent and may have reduced effectiveness on slopes between 6 to 15 percent.

3. The design should be based on the same methods detailed for swales. The preferred geometry of a filter strip is rectangular, and this should be used when

applying the design procedures of vegetated swales.

When using this procedure, the following provisions apply specifically to filter strips (Horner, 1993):

(1) Slopes should be no greater than 15 percent and should preferably be lower than 5 percent, and be uniform throughout the strip after final grading.
(2) Hydraulic residence time normally no less than 9 minutes, and in no case less than 5 minutes.
(3) Average velocity no greater than 0.9 feet/second.
(4) Manning's friction factor (*n*) of 0.02 should be used for grassed strips, *n* of 0.024 if strip is infrequently mowed, or a selected higher value if the strip is wooded.
(5) The width should be no greater than that where a uniform flow distribution can be assured.
(6) Average depth of flow (design depth) should be no more than 0.5 inches.
(7) Hydraulic radius is taken to be equal to the design flow depth.

5. Filter strips function best with longitudinal slopes less than 10 percent, and ideally less than 5 percent. As filter strip length becomes shorter, slope becomes more influential. Therefore, when a minimum strip length of 20 feet is utilized, slopes should be graded as close to zero as drainage permits (Schueler, 1987). With steeper slopes, terracing through using landscape timber, concrete weirs, or other means may be required to maintain sheet flow.
6. Calculate the flow rate of stormwater to be mitigated by the vegetated filter strip using the Los Angeles County Department of Public Works *Method for Calculating Standard Urban Stormwater Mitigation Plan (SUSMP) Flow Rates and Volumes Based on 0.75-inches of Rainfall*. A minimum of 8 feet is recommended for filter strip width.
7. Another design issue is runoff collection and distribution to the strip, and release to a transport system or receiving water (Horner, 1985). Flow spreader devices should be used to introduce the flow evenly to the filter strip (Urbonas, 1992). Concentrated flow needs to use a level spreader to evenly distribute flow onto a strip. There are many alternative spreader devices, with the main consideration being that the overland flow spreader be distributed equally across the strip. Level spreader options include porous pavement strips, stabilized turf strips, slotted curbing, rock-filled trench, concrete sills, or plastic-lined trench that acts as a small detention pond (Yu and Kaighn, 1992). The outflow and filter side lip of the spreader should have a zero slope to ensure even runoff distribution (Yu and Kaighn, 1992). Once in the filter strip, most runoff from significant events will not be infiltrated and will require a collection and conveyance system. Grass-lined swales are often used for this purpose and can provide another BMP level. A filter strip can also drain to a storm sewer or street gutter (Urbonas, 1992).

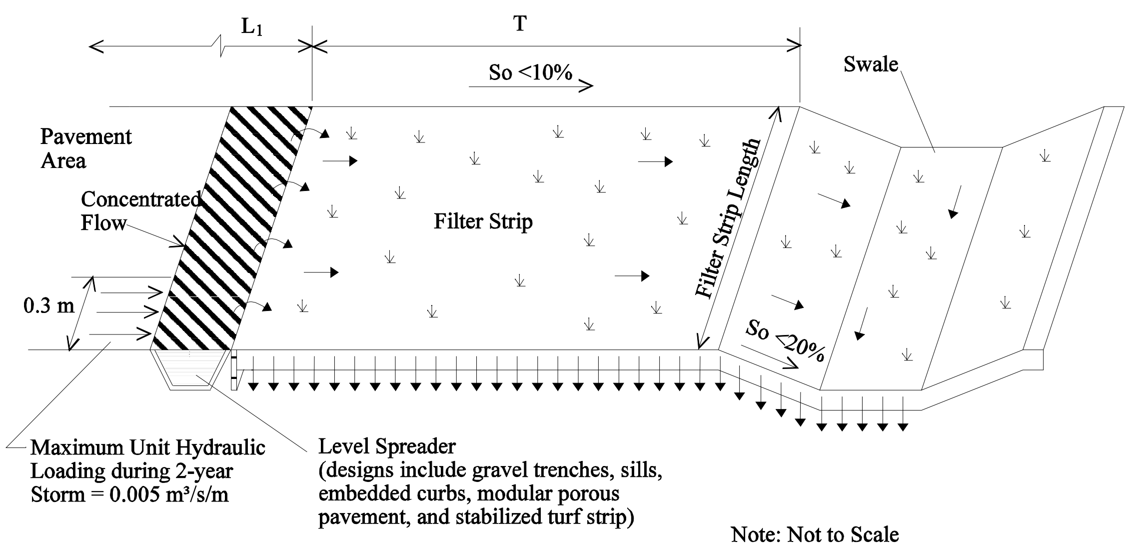

Figure 2. Sample filter strip design (Urbonas, 1992).

8. Filter strips should be constructed of dense, soil-binding deep-rooted water-resistant plants. For grassed filter strips, dense turf is needed to promote sedimentation and entrapment, and to protect against erosion (Yu and Kaighn, 1992). Turf grass should be maintained to a blade height of 2 to 4 inches. Most engineered, sheet-flow systems are seeded with specific grasses. Common grasses established for filter strip systems are rye, fescue, reed canary, and Bermuda (Horner, 1985). Tall fescue and orchard grasses grow well on slopes and under low nutrient conditions (Horner, 1985). The grass species chosen should be appropriate for the climatic conditions and maintenance criteria for each project.
9. Trees and woody vegetation have been shown to increase infiltration and improve performance of filter strips. Trees and shrubs provide many stormwater management benefits by intercepting some rainfall before it reaches the ground, and improving infiltration and retention through the presence of a spongy, organic layer of materials that accumulates underneath the plants (Schueler, 1987). As discussed previously in this section, wooded strips have shown significant increases in pollutant removal over grass strips. Maintenance for wooded strips is virtually non-existent, another argument for using trees and shrubs. However, there are drawbacks to using woody plants. Since the density of the vegetation is not as great as a turf grass cover, wooded filter strips need additional length to

accommodate more vegetation. In addition, shrub and tree trunks can cause uneven distribution of sheet flow, and increase the possibility for development of gullies and channels. Consequently, wooded strips require flatter slopes than a typical grass cover strip to ensure that the presence of heavier plant stems will not facilitate channelization.

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The following is a known location where a Vegetated Filter Strip was installed. The design of the installed strip in the location may vary from what is recommended in this SUSMP due to its specific circumstances. Los Angeles County does not endorse nor warranty any design used in the location herein. Each individual case may require that the design be tailored to perform properly.

Installed Location (City/Address)	Brand/Manufacturer	Owner/Client

I-605/SR91	N/A	Caltrans

B.13 VEGETATIVE SWALE

DESCRIPTION

Vegetated swales are shallow vegetated channels to convey stormwater where pollutants are removed by filtration through grass and infiltration through soil. They look similar to, but are wider than, a ditch that is sized only to transport flow. They require shallow slopes and soils that drain well. Grassed swale designs have achieved mixed performance in pollutant removal efficiency. Moderate removal rates have been reported for suspended solids and metals associated with particulates such as lead and zinc. Runoff waters are typically not detained long enough to effectively remove very fine suspended solids, and swales are generally unable to remove significant amounts of dissolved nutrients. Pollutant removal capability is related to channel dimensions, longitudinal slope, and type of vegetation. Optimum design of these components will increase contact time of runoff through the swale and improve pollutant removal rates.

Vegetated swales are primarily stormwater conveyance systems. They can provide sufficient control under light to moderate runoff conditions, but their ability to control large storms is limited. Therefore, they are most applicable in low to moderate sloped areas as an alternative to ditches and curb and gutter drainage. Their performance diminishes sharply in highly urbanized settings. Vegetated swales are often used as a pretreatment measure for other downstream BMPs, particularly infiltration devices. Enhanced vegetative swales utilize check dams and wide depressions to increase runoff storage and promote greater settling of pollutants.

ADVANTAGES

1. Relatively easy to design, install and maintain.
2. Vegetated areas that would normally be included in the site layout, if designed for appropriate flow patterns, may be used as a vegetated swale.
3. Relatively inexpensive.
4. Vegetation is usually pleasing to residents.

LIMITATIONS

1. Irrigation may be necessary to maintain vegetative cover.
2. Potential for mosquito breeding areas.
3. Possibility of erosion and channelization over time.
4. Requires dry soils with good drainage and high infiltration rates for better pollutant removal.

5. Not appropriate for pollutants toxic to vegetation.
6. Large area requirements may make this BMP infeasible for some sites.
7. Used to serve sites less than 10 acres in size, with slopes no greater than 5 percent.
8. The seasonal high water table should be at least 2 feet below the surface.
9. Buildings should be at least 10 feet from the site.

DESIGN CRITERIA

Several criteria should be kept in mind when beginning swale design. These provisions, presented in Table 1, have been developed through a series of evaluative research conducted on swale performance.

Table 1. Criteria for optimum swale performance (Horner, 1993).

Parameter	*Optimal Criteria*	*Minimum Criteria**
Hydraulic Residence Time	9 min	$\geq$ 5 min
Average Flow Velocity	$\leq$ 0.9 ft/s	
Swale Width	8 ft	2 ft
Swale Length	200 ft	100 ft
Swale Slope	~ 2 - 6%	~ 1%
Side Slope Ratio (horizontal:vertical)	4 : 1	2 : 1

* Criteria at or below minimum values can be used when compensatory adjustments are made to the standard design. Specific guidance on implementing these adjustments will be discussed in the design section.

The procedures described below were set forth by Horner, and unless otherwise cited, are set forth in *Biofiltration for Stormwater Runoff Quality Control*, published in 1993. The following steps are recommended to be conducted in order to complete a swale design:

(1) Determine the flow rate to the system.
(2) Determine the slope of the system.
(3) Select a swale shape (skip if filter strip design).
(4) Determine required channel width.
(5) Calculate the cross-sectional area of flow for the channel.
(6) Calculate the velocity of channel flow.
(7) Calculate swale length.
(8) Select swale location based on the design parameters.
(9) Select a vegetation cover for the swale.
(10) Check for swale stability.

Recommended procedures for each task are discussed in detail below.

1. *Determine Flow Rate to the System.* Calculate the flow rate of stormwater to be mitigated by the vegetated swale using the Los Angeles County Department of Public Works *Method for Calculating Standard Urban Stormwater Mitigation Plan (SUSMP) Flow Rates and Volumes Based on 0.75-inches of Rainfall*. Runoff from larger events should be designed to bypass the swale, consideration must be given to the control of channel erosion and destruction of vegetation. A stability analysis for larger flows (up to the 100-yr 24-hour) must be performed. If the flow rate approaches or exceeds 1 ft^3/s, one or more of the design criteria in Table 1 may be violated, and the swale system may not function correctly (Washington State Department of Transportation, 1995). Alternative measures to lower the design flow should be investigated. Possibilities include dividing the flow among several swales, installing detention to control release rate upstream, and reducing developed surface area to reduce runoff coefficient value and gain space for biofiltration (Horner, 1993).
2. *Determine the Slope of the System.* The slope of the swale will be somewhat dependent on where the swale is placed, but should be between the stated criteria of one and six percent.
3. *Select a Swale Shape.* Normally, swales are designed and constructed in a trapezoidal shape, although alternative designs can be parabolic, rectangular, and triangular. Trapezoidal cross-sections are preferred because of relatively wider vegetative areas and ease of maintenance (Khan, 1993). They also avoid the sharp corners present in V-shaped and rectangular swales, and offer better stability than the vertical walls of rectangular swales.
4. *Determine Required Channel Width.* Estimates for channel width for the selected shape can be obtained by applying Manning's:

$$Q = \frac{1.486 A R_h^{0.667} S^{0.5}}{n} \tag{1}$$

Where:

Q	=	Flow (ft^3/s).
A	=	Cross-sectional area of flow (ft^2).
R_h	=	Hydraulic radius of flow cross section (ft).
S	=	Longitudinal slope of biofilter (ft/ft).
n	=	Manning's roughness coefficient.

A Manning's n value of 0.02 is used for routine swales that will be mowed with some regularity. For swales that are infrequently mowed, use a Manning's n value of 0.024. A higher n value can be selected if it is known that vegetation will be very dense (Khan, 1993).

Figure 1 presents channel geometry and equations for a trapezoidal swale, the most frequently used shape.

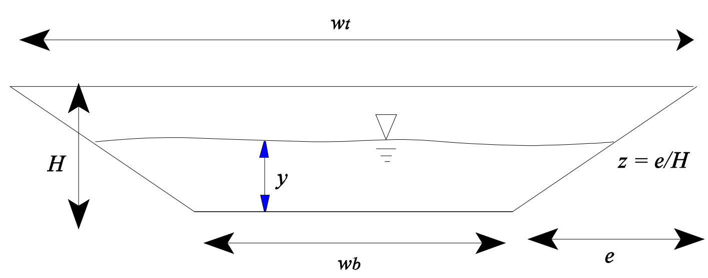

Figure 1. Channel geometry for a trapezoid swale.

$$Cross\ \ Sectional\ \ Area\,(A_x) = by + zy^2$$

$$Width\,(w) = b + 2yz$$

$$Hydraulic\ \ Radius\,(R_h) = \frac{by + zy^2}{by + 2y\sqrt{z^2+1}}$$

Substituting the geometric equations presented in Figure 1 into Manning's equation, the bottom width (w_b) and the top width (w_t) for the trapezoid swale can be computed using the following equations:

$$w_b \cong \frac{Qn}{y^{1.67} s^{0.5}} - zH \qquad (2)$$

$$w_t = w_b + 2zH \qquad (3)$$

Where:

Q = Flow rate in ft^3/s.

n	=	Manning's roughness coefficient.
y	=	Depth of flow.
H	=	The side slope in the form of z:1.

For trapezoidal and the limited case of V-shapes, the side slope (z) used should be at least 3:1 (horizontal:vertical). V-shaped swales should be double checked after computation of w_t to make sure that $z = 2w_t$ is at least 3. If a slope steeper than 2:1 must be used, additional stabilization measures (i.e., lining the swale with riprap) may be needed.

Typically, the depth of flow in the channel (H) is set at 3 to 4 inches. Flow depth can also be determined by subtracting 2 inches from the expected grass height, if the grass type and the height it will be maintained is known. Values lower than 3 to 4 inches can be used, but doing so will increase the computed width (w_t or w_b) of the swale (Washington State Department of Transportation, 1995).

Swale width computed should be between 2 to 8 feet. Relatively wide swales (those wider than 8 feet are more susceptible to flow channelization and are less likely to have uniform sheet flow across the swale bottom for the entire swale length. The maximum widths for swales is on the order of 10 feet, however widths greater than 8 feet should be evaluated to consider the effectiveness of the flow spreading design used and the likelihood of maintaining evenness in the swale bottom. Since length may be used to compensate for width reduction (and vice versa) so that area is maintained, the swale width can be arbitrarily set to 8 feet to continue with the analysis. If b is less than 2 feet, set b = 2 feet and continue. Narrower widths can be used if space is very constrained. Sometimes when the flow rate is very low, the equation above can generate a negative value for w_b. Since this is not possible, the bottom width should be set to 1 feet when this occurs.

5. *Calculate Cross-Sectional Area.* Compute the cross-sectional area (A) for the swale, using the following equation:

$$A_x = (w_b + 2zH)yH \tag{4}$$

6. *Calculate the Velocity of the Channel Flow.* Channel flow velocity (U) can be computed using the continuity equation:

$$U = \frac{Q}{A_x} \tag{5}$$

This velocity should be less than 0.9 ft/s, a velocity that was found to cause grasses to be flattened, reducing filtration. A velocity lower than this maximum value is recommended to achieve the 9-minute hydraulic residence time criterion, particularly in shorter swales (at U = 0.9 ft/s, a 485-ft swale is needed for a 9-min residence time and a 269-ft swale for a 5-min residence time).

If the value of U suggests that a longer swale will be needed than space permits, investigate how the design flow Q can be reduced, or increase flow depth (H) and/or swale width (w_t) up to the maximum allowable values and repeat the analysis.

7. *Calculate Swale Length.* Compute the swale length (L) using the following equation:

$$L = Ut_r\ (60\ s/\text{min}) \tag{6}$$

Where:

t_r = Hydraulic residence time (in minutes).

Use t_r = 9 min for this calculation.

If a swale length greater than the space will permit results, investigate how the design flow Q can be reduced. Increase flow depth (H) and/or swale width (w_b) up to the maximum allowable values and repeat the analysis. If all of these possibilities are checked and space is still insufficient, t can be reduced, but to no less than 5 minutes. If the computation results in L less than 100 ft, set L = 100 ft and investigate possibilities in width reduction. This is possible through recalculating U at the 100-ft length, recomputing cross-sectional area, and ultimately adjusting the swale width w_b using the appropriate equation.

8. *Select Swale Location.* Swale geometry should be maximized by the designer, using the above equations, and given the area to be utilized. If the location has not yet been chosen, it is advantageous to compute the required swale dimensions and then select a location where the calculated width and length will fit. If locations available cannot accommodate a linear swale, a wide-radius curved path can be used to gain length. Sharp bends should be avoided to reduce erosion potential. Regardless of when and how site selection is performed, consideration should be given to the following site criteria:

Soil Type. Soil characteristics in the swale bottom should be conducive to grass growth. Soils that contain large amounts of clay cause relatively low permeability and result in standing water, and may cause grass to die. Where the potential for leaching into groundwater exists, the swale bottom may need to be sealed with clay to protect from infiltration into the resource. Compacted soils will need to be tilled before seeding or planting. If topsoil is required to facilitate grass seeding and growth, use 6 inches of the following recommended topsoil mix: 50 to 80 percent sandy loam, 10 to 20 percent clay, and 10 to 20 percent composted organic matter (exclude animal waste).

Slope. The natural slope of the potential location will determine the nature and amount of regrading, or if additional measures to reduce erosion and/or increase pollutant removal are required. Swales should be graded carefully to attain uniform longitudinal and lateral slopes and to eliminate high and low spots. If needed, grade control checks should be provided to maintain the computed longitudinal slope and limit maximum flow velocity (Urbonas, 1992).

Natural Vegetation. The presence and composition of existing vegetation can provide valuable information on soil and hydrology. If wetland vegetation is present, inundated conditions may exist at the site. The presence of larger plants, trees and shrubs, may provide additional stabilization along the swale slopes, but also may shade any grass cover established. Most grasses grow best in full sunlight, and prolonged shading should be avoided. It is preferable that vegetation species be native to the region of application, where establishment and survival have been demonstrated.

9. *Select Vegetative Cover.* A dense planting of grass provides the filtering mechanism responsible for water quality treatment in swales. In addition, grass has the ability to grow through thin deposits of sediment and sand, stabilizing the deposited sediment and preventing it from being resuspended in runoff waters. Few other herbaceous plant species provide the same density and surface per unit area. Grass is by far the most effective choice of plant material in swales, however not all grass species provide optimum vegetative cover for use in swale systems. Dense turf grasses are best for vegetative cover. Table 2 lists several turf grasses, and their suitability in terms of cold tolerance, heat tolerance, mowing height adaptation, drought tolerance, and maintenance cost and effort.

In areas of poor drainage, wetlands species can be planted for increased vegetative cover. Use wetland species that are finely divided like grass and relatively resilient. Invasive species, such as cattails, should be avoided to eliminate proliferation in the swale and downstream.

Woody or shrubby plantings can be used for landscaping on the edge of side slopes, but not in the swale treatment area. Trees and shrubs can provide some additional stabilization, but also mature and shade the grass. In addition, leaf or needle drop can contribute unwanted nutrients, create debris jams, or interfere with waterflow through the system. If landscape plantings are to be used, selection and planting processes should be carefully planned and carried out to avoid these potential problems.

	Cold Tolerance	Heat Tolerance	Mowing Height	Drought Tolerance	Maintenance
High	Creeping bentgrass Kentucky bluegrass Red fescue Colonial bentgrass Highland bentgrass	Zoysia grass Hybrid bermuda grass Common bermuda grass St Augustine grass Kikuyu grass	Tall fescue	Hybrid bermuda grass Zoysia grass Common bermuda grass	Creeping bentgrass Dichondra
			Red fescue Kentucky bluegrass Perennial ryegrass Weeping alkali grass	St Augustine grass Kikuyu grass	Hybrid bermuda grass
		Tall fescue Dichondra Creeping bentgrass			
		Kentucky bluegrass	St. Augustinegrass Common bermudagrass		Kentucky bluegrass Colonial bentgrass Perennial ryegrass
	Tall fescue Weeping alkali grass	Highland bentgrass Perennial ryegrass Colonial bentgrass	Dichondra Kikuyugrass Colonial bentgrass Highland bentgrass Zoysiagrass	Tall fescue Red fescue	St. Augustine grass Highland bentgrass Zoysia grass
			Hybrid bermudagrass		
Low	Dichondra Zoysia grass Common bermuda grass Hybrid bermuda grass Kikuyu grass St. Augustine grass	Weeping alkaligrass Red fescue	Creeping bentgrass	Kentucky bluegrass Perennial ryegrass Highland bentgrass Creeping bentgrass Colonial bentgrass Weeping alkaligrass Dichondra	Tall fescue Common bermuda grass Kikuyu grass

Table 2. Criteria for turf grass cover
(Camp, Dresser and McKee, 1993.)

10. *Check Swale Stability.* The stability check is performed for the combination of highest expected flow and least vegetation coverage and height. Stability is normally checked for flow rate (Q) for the 100-yr, 24-h storm unless runoff from larger such events will bypass the swale. Q can be determined using the same methods mentioned for the initial design storm computation. The maximum velocity (U_{max}) in ft/s, that is permissible for the vegetation type, slope, and soil conditions should be obtained. Table 3 provides maximum velocity data for a variety of vegetative covers and slopes.

Table 3. Guide for selecting maximum permissible swale velocities for stability (adapted from Chow [1959], Livingston, et al., [1984], and Goldman, et al., [1986] from Horner [1993]).

Cover Type	Slope (%)	Maximum Velocity (ft/s) Erosion-resistant soils	Maximum Velocity (ft/s) Easily eroded soils
Kentucky bluegrass Tall fescue	0 - 5	6	5
Kentucky bluegrass Ryegrasses Western wheat-grass	5 - 10	5	4
Grass-legume Mixture	0 - 5 5 - 10	5 4	4 3
Red fescue	0 - 5	3	2.5

The estimated degree of retardance for different grass coverage ("good" or "fair") should be obtained for the selected vegetation height. Estimation should be based on coverage and height will first receive flow, or whenever coverage and height are at their lowest. Table 4 provides qualitative degree of retardance for coverage and grass height.

Table 4. Grass coverage, height, and degree of retardance (Horner, 1993).

Average Grass Height (mm [inches])	Degree of Retardance
Coverage = "Good"	
> 760 (30)	A. Very high
280 - 610 (11 -24)	B. High
150 - 270 (6 - 10)	C. Moderate
50 - 150 (2 - 6)	D. Low
> 50 (>2)	E. Very low
Coverage = "Fair"	
> 760 (30)	B. High
280 - 610 (11 -24)	C. Moderate
150 - 270 (6 - 10)	D. Low
50 - 150 (2 - 6)	D. Low
> 50 (>2)	E. Very low

Select a trial Manning's n value for poor vegetation cover and low height. A good initial choice is n = 0.04. Using the alphabetic code assigned for the degree of retardance and the chosen n value, consult the following graph to obtain a first approximation for UR_h (velocity x hydraulic radius).

The graph in Figure 2 was derived based on English units. Compute the hydraulic radius, using the U_{max} determined for vegetation type and slope, by applying the following equation:

$$UR_h = \frac{UR_h}{U_{\max}} \tag{7}$$

Use Manning's equation to solve for the actual UR_h:

$$VR = \frac{1}{n} R^{1.67} s^{0.5} \tag{8}$$

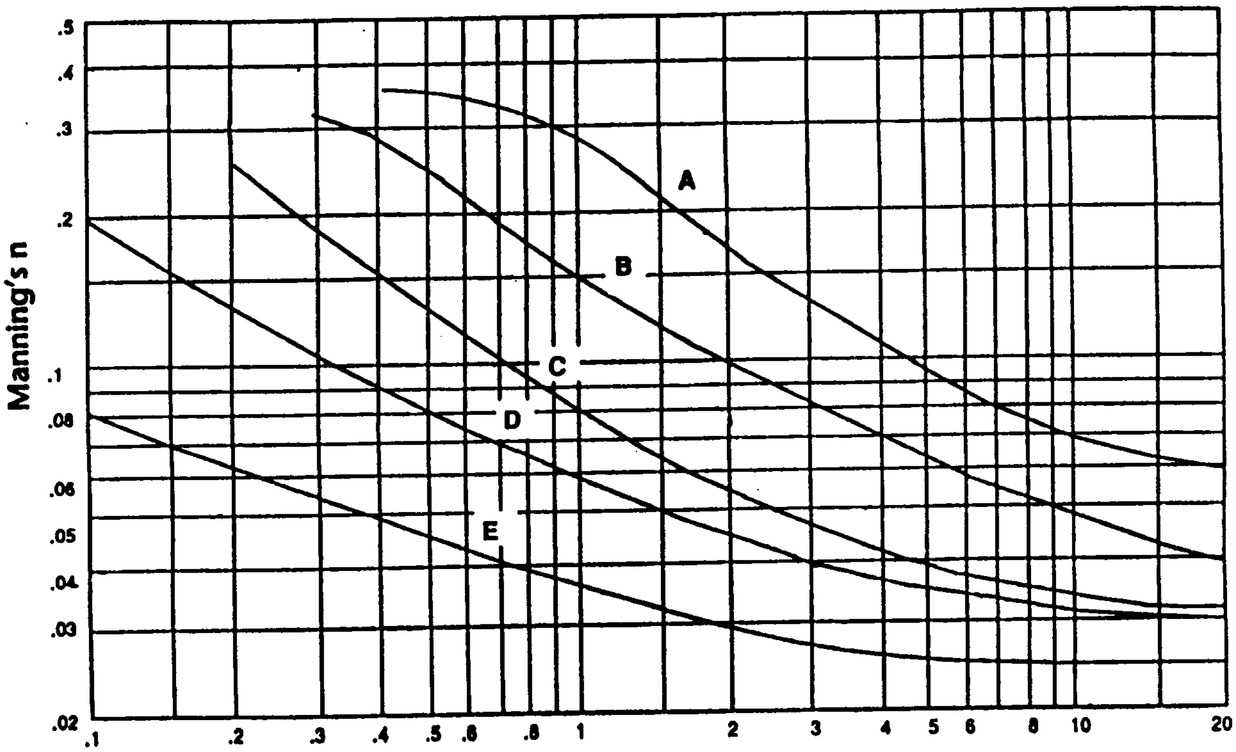

Figure 2. Relationship of Manning's n with UR_h for various degrees of flow retardance.

Once the actual UR_h is determined, compare this value with the first approximation for UR_h obtained through Figure 2. If they do not agree within five percent, adjust Manning's n value and repeat the process until acceptable agreement is reached. If $n < 0.033$ is needed to get agreement, set $n = 0.033$, solve UR_h again using Manning's equation above, and proceed.

The actual velocity for the final design conditions should be computed using the following equation:

$$U = \frac{UR_h}{R_h} \tag{9}$$

The actual velocity U should be less than the U_{max} value obtained from Table 3.

The area (A_x) required for stability should be computed from the following equation:

$$A_x = \frac{Q}{U} \tag{10}$$

The area value obtained in this procedure should be compared with the area (A_x) value obtained in the capacity analysis. If less area is required for stability than is provided for capacity, the design is acceptable. If more area is required for stability, use the area (A_x) value obtained in the stability analysis to recalculate channel dimensions.

The depth of flow at the stability check design flow rate then needs to be computed for the final dimensions of the swale by solving for y in the area equations provided on Figure 2. Compare this flow depth to the depth used in the capacity design. The larger of the two values should be used, plus 1 ft of freeboard, to obtain the total depth of the swale. The top width for the full depth of the swale should than be recalculated.

As a final check for capacity should be performed based on the stability check design storm, maximum vegetation height and cover to ensure that capacity is adequate if the largest expected event coincides with the greatest retardance. Using Manning's equation, the Manning's n value used for capacity design, and the calculated channel dimension (including freeboard) to compute the flow capacity of the channel. If the flow capacity is less than the stability check design storm flow rate, increase the channel cross-sectional area as needed for this conveyance, and specify the new channel dimensions.

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12. Washington State Department of Transportation, 1995. *Highway Runoff Manual*, Washington State Department of Transportation.

The following is a list of known locations where a Vegetated Swale was installed. The design of the installed swale in each location may vary from what is recommended in this SUSMP due to its specific circumstances. Los Angeles County does not endorse nor warranty any design used in the locations herein. Each individual case may require that the design be tailored to perform properly.

Installed Location (City/Address)	Brand/Manufacturer	Owner/Client
Cerritos Maintenance Station	N/A	Caltrans
I-605/Del Amo Ave.	N/A	Caltrans

B.14 WET PONDS

DESCRIPTION

The wet pond or retention pond is a facility which removes sediment, Biochemical Oxygen Demand (BOD), organic nutrients, and trace metals from stormwater runoff. This is accomplished by slowing down stormwater using an in-line permanent pool or pond effecting settling of pollutants. The wet pond is similar to a dry pond, except that a permanent volume of water is incorporated into the design. The drainage area should be such that an adequate base flow is maintained in the pond. Biological processes occurring in the permanent pond pool aid in reducing the amount of soluble nutrients present in the water, such as nitrate and ortho-phosphorus (Schueler, 1987).

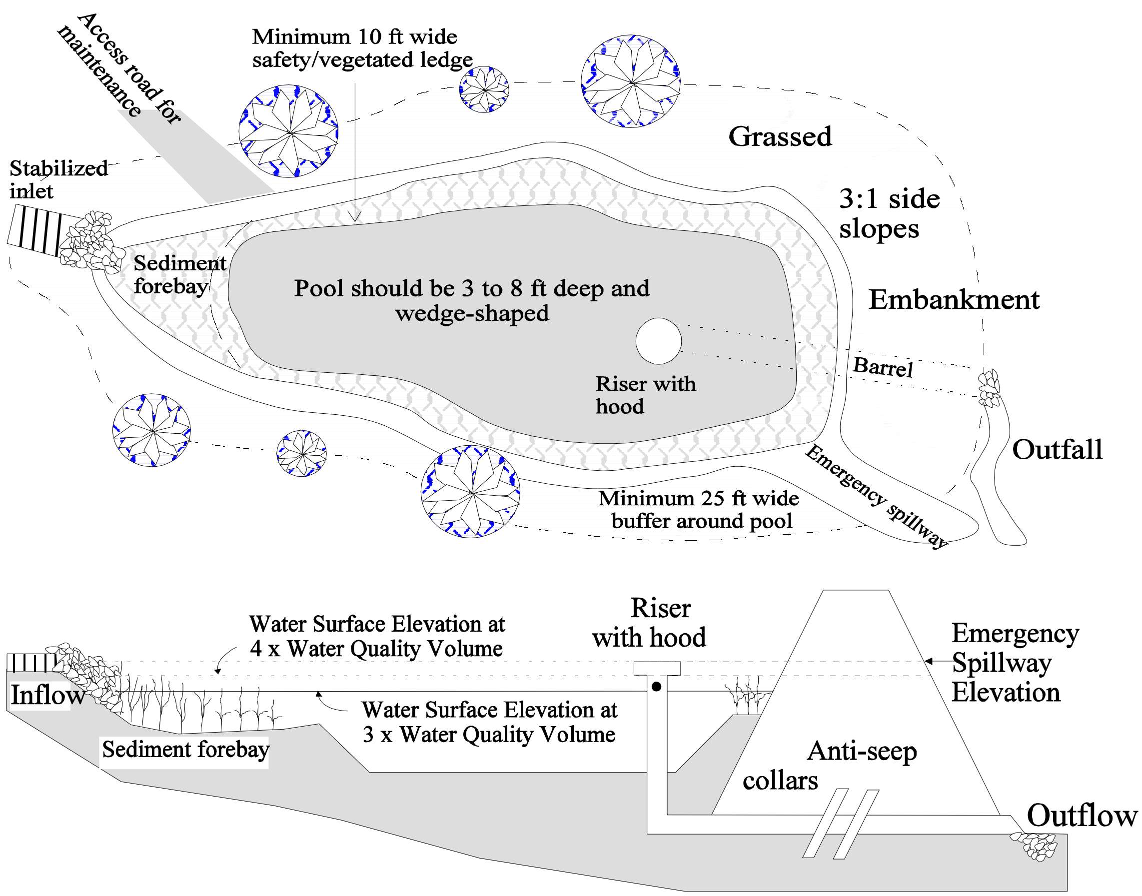

Figure 1. Typical wet pond schematic.

The basic elements of a wet pond are shown in Figure 1. A stabilized inlet prevents erosion at the entrance to the pond. It may be necessary to install energy dissipators. The permanent pool is usually maintained at a depth between 3 and 8 ft. The shape of the pool can help improve the performance of the pond. Maximizing the distance between the inlet and outlet provides more time for mixing of the new runoff with the pond water and settling of pollutants. Overflow from the pond is released through outlet structures to discharge flows at various elevations and peak flow rates. The outfall channel should be protected to prevent erosion from occurring downstream of the outlet.

Soil conditions are important for the proper functioning of the wet pond. The pond is a permanent pool, and thus must be constructed such that the water must not be allowed to infiltrate from the permanent portion of the pool. It is difficult to form a pool in soils with high infiltration rates soon after construction. Eventually, however, deposition of silt at the bottom of the pond will help slow infiltration. If extremely permeable soils exist at the site (type A or B), a geotextile or clay liner may be necessary.

ADVANTAGES

1. Wet ponds have recreational and aesthetic benefits due to the incorporation of permanent pools in the design.
2. Wet ponds offer flood control benefits in addition to water quality benefits.
3. Wet ponds can be used to handle a maximum drainage area of 10 mi^2.
4. High pollutant removal efficiencies for sediment, total phosphorus, and total nitrogen are achievable when the volume of the permanent pool is at least three times the water quality volume (the volume to be treated).
5. A wet pond removes pollutants from water by both physical and biological processes, thus they are more effective at removing pollutants than extended/dry detention basins.
6. Creation of aquatic and terrestrial habitat.

LIMITATIONS

1. Wet ponds may be feasible for stormwater runoff in residential or commercial areas with a combined drainage area greater than 20 acres but no less than 10 acres.
2. An adequate source of water must be available to ensure a permanent pool throughout the entire year.
3. If the wet pond is not properly maintained or the pond becomes stagnant; floating debris, scum, algal blooms, unpleasant odors, and insects may appear.
4. Sediment removal is necessary every 5 to 10 years.
5. Heavy storms may cause mixing and subsequent resuspension of solids.
6. Evaporation and lowering of the water level can cause concentrated levels of salt and algae to increase.
7. Cannot be placed on steep unstable slopes.
8. In California, the wet season in coincident with minimal plant growth.
9. Could be regulated as a wetlands or under Chapter 15, Title 23, California Code of Regulations regarding waste disposal to lands.
10. Pending volume and depth, pond designs may require approval from State Division of Safety of Dams.

DESIGN CRITERIA

1. *Hydrology*. If the device will also be used for stormwater quantity control, it will be necessary to reduce the peak flows after development to pre-development levels.
2. *Volume*. Calculate the volume of stormwater to be mitigated by the wet pond using the Los Angeles County Department of Public Works *Method for Calculating Standard Urban Stormwater Mitigation Plan (SUSMP) Flow Rates and Volumes Based on 0.75-inches of Rainfall*. The volume of the permanent pool should be 3 times the water quality volume.
3. *Pond Shape*. The pond should be long and narrow and generally shaped such that it discourages "short-circuiting." Short-circuiting occurs when storm flows by-pass the pond and do not mix well with the pool and simply by-pass the pond. Short-circuiting can be discouraged by lengthening the pond or by installing baffles which slow water down and lengthen the distance between the inlet and outlet. A length to width ratio of no less than 2:1, with 4:1 being preferred, will help minimize short circuiting. Also, the pond should gradually expand from the inlet and gradually contract toward the outlet. Several examples of ponds shaped to reduce short-circuiting are shown in Figure 2.
4. *Depth*. The depth of the pond is important in the design of the pond. If the pond is too shallow, sediment will be easily resuspended as a result of wind. Shallow ponds should not be used unless vegetation is adequate to stabilize the pond. If the pond is too deep, safety considerations emerge and stratification may occur, possibly causing anoxic conditions near the bottom of the pond. If the pond becomes anoxic, pollutants adsorbed to the bottom sediments may be released back to the water column. The average depth should be 3 to 6 ft, and depths of more than 8 ft should be avoided (Schueler, 1987). A littoral zone of 6 to 18 inches deep that accounts for 25 to 50 percent of the permanent pool surface for plant growth along the perimeter of the pool is recommended, the littoral shelf will also enhance safety.
5. *Vegetation.* Planting vegetation around the perimeter of the pond can have several advantages. Vegetation reduces erosion on both the side slopes and the shallow littoral areas. Vegetation located near the inlet to the pond can help trap sediments; algae growing on these plants can also filter soluble nutrients in the water column. Thicker, higher vegetation can also help hide any debris which may collect near the shoreline. Native turf-forming grasses or irrigated turf should be planted on sloped areas, and aquatic species should be planted on the littoral areas (Urbonas, et al., 1992). Vegetation can benefit wildlife and waterfowl by providing food and cover at the marsh fringe. A shallow, organic-rich marsh fringe provides an area which enables bacteria and other microorganisms to reduce organic matter and nutrients (Schueler, 1987).
6. *Side Slopes.* Gradual side slopes of a wet pond enhance safety and help prevent erosion and make it easier to establish dense vegetation. If vegetation cannot be established, the unvegetated banks will add to erosion and subsequently the

sediment load. It is recommended that side slopes be no greater than 3:1. If slopes are greater than this, riprap should be used to stabilize the banks (Schueler, 1987).

7. *Hydraulic Devices*. An outlet device, typically a riser-pipe barrel system, should be designed to release runoff in excess of the water quality volume and to control storm peaks. The outlet device should still function properly when partial clogging occurs. Plans should provide details on all culverts, risers, and spillways. Calculations should depict inflow, storage, and outflow characteristics of the design. Some frequently used design details for extending detention times in wet ponds are shown in Figure 3 and are described below (Schueler, 1987):

   a. *Slotted Standpipe from Low-Flow Orifice, Inlet Control (dry pond, shallow wet pond, or shallow marsh) [Figure 3 (a)].* An "L"-shaped PVC pipe is attached to the low-flow orifice. An orifice plate is located within the PVC pipe which internally controls the release rate. Slots or perforations are all spaced vertically above the orifice plate, so that sediment deposited around the standpipe will not impede the supply of water to the orifice plate.
   b. *Negatively Sloped Pipe from River (wet ponds or shallow marshes) [Figure 3 (b)].* This design was developed to allow for extended detention in wet ponds. The release rate is governed merely by the size of the pipe. The risk of clogging is largely eliminated by locating the opening of the pipe at least 1 ft below the water surface where it is away from floatable debris. Also, the negative slope of the pipe reduces the chance that debris will be pulled into the opening by suction. As a final defense against clogging, the orifice can be protected by wire mesh.
   c. *Hooded Riser (wet ponds) [Figure 3 (c)].* In this design, the extended detention orifice is located on the face of the riser near the top of the permanent pool elevation. The orifice is protected by wire mesh and a hood, which prevents floatable debris from clogging the orifice.

8. *Inlet and Outlet Protection.* The inlet pipe should discharge at or below the water surface of the permanent pool. If it is above the pool, an outlet energy dissipator will protect the banks and side slopes of the pond to avoid erosion. The stream channel just downstream of the pond outlet should be protected from scouring by placing riprap along the channel. Also, the slope of the outlet channel should be close to 0.5 percent. Riprap between 18 and 30 inches should be used. If the outlet pipe is less than 24 inches, 9 to 12 inches riprap may be used. Stilling basins may also be installed to reduce flow velocities at the outfall (Schueler, 1987).
9. *Forebay.* A forebay may be installed as part of the wet pond to capture sand and gravel sediment. The forebay should be easily accessible for dredging out the sediment when necessary and access to the forebay for equipment should be provided.

10. *Emptying Time*. A 12 to 48 hour emptying time may be used for the water quality volume above the permanent pool (Urbonas, et al., 1992).
11. *Freeboard.* The pond embankment should have at least 1 ft of freeboard above the emergency spillway crest elevation (Schueler, 1987).

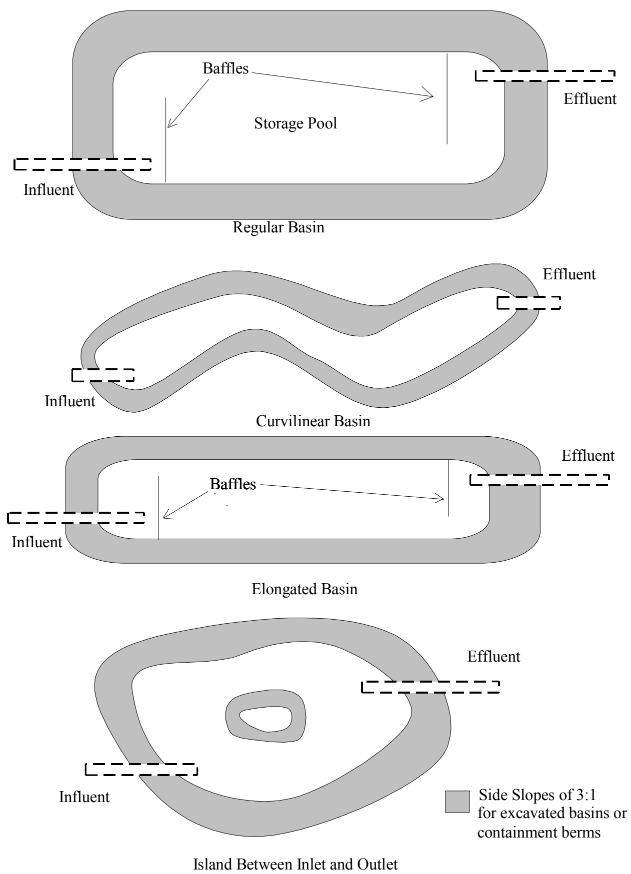

Figure 2. Methods of increasing the length to width ratio.

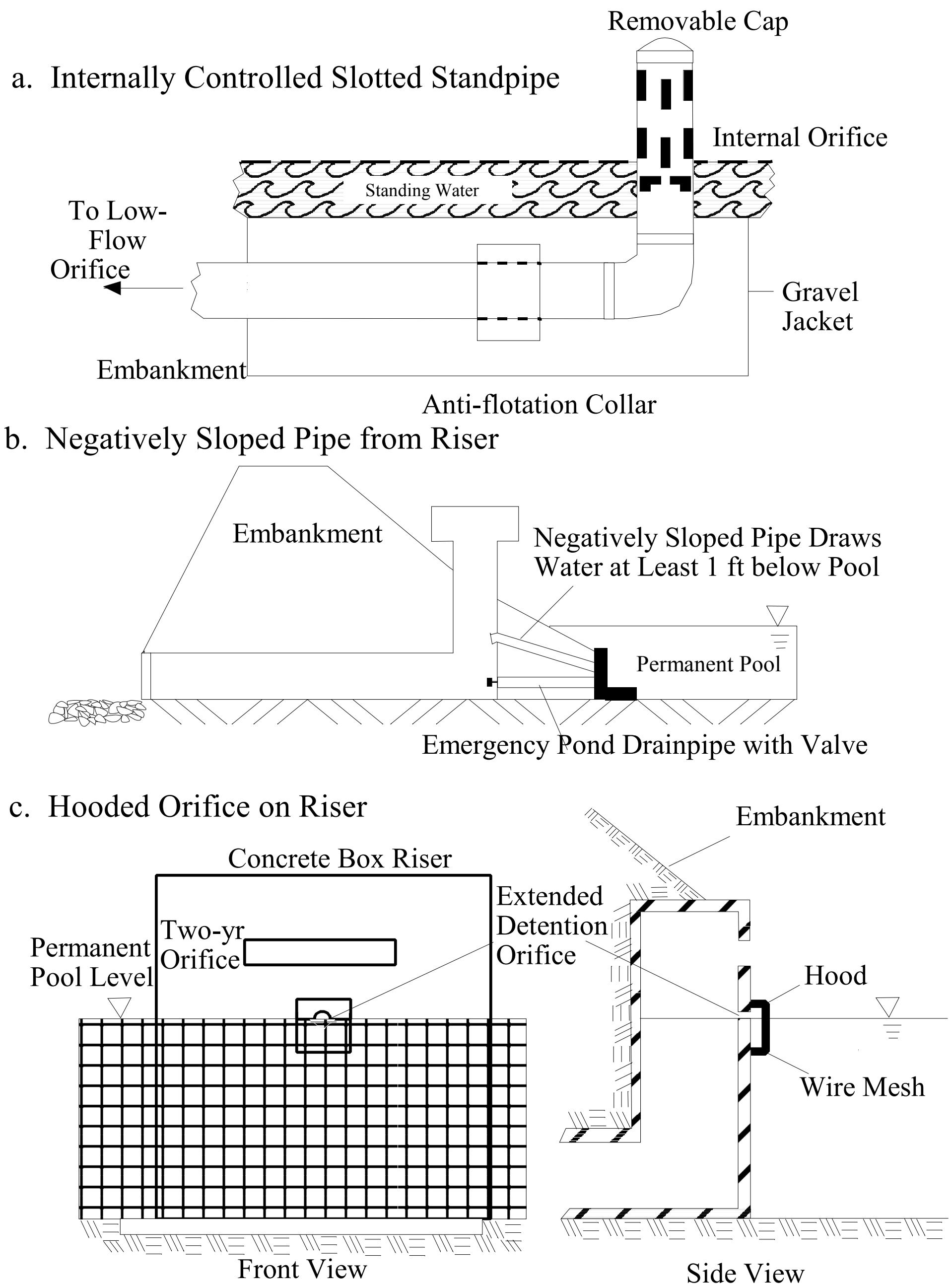

Figure 3. Designs or approaches for extending detention times in wet ponds.

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